Stabilisation of the emergency patient Part I: Airway and breathing

Sigrist, Nadja

Abstract: Patients with respiratory distress are, regardless of the underlying cause, emergency patients and the initial approach to these patients determines prognosis and survival. Animals with respiratory distress are stressed which makes most diagnostic procedures impossible or counter-productive. By localising the respiratory problem using the initial clinical exam of the animal, the clinician can narrow down the causes of respiratory distress. Looking at the type of breathing, type of dyspnoea and using auscultation findings and information from the history, the problem can be localised, limiting possible differential diagnoses. This allows institution of not only supportive measures such as oxygen supplementation, stress-free handling or analgesia but also a more specific therapy of the problem causing respiratory distress. The stabilised animal can then undergo further diagnostic procedures and receive specific treatment.

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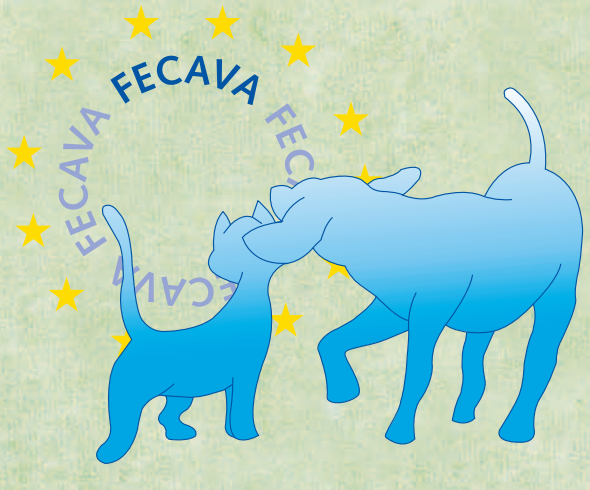

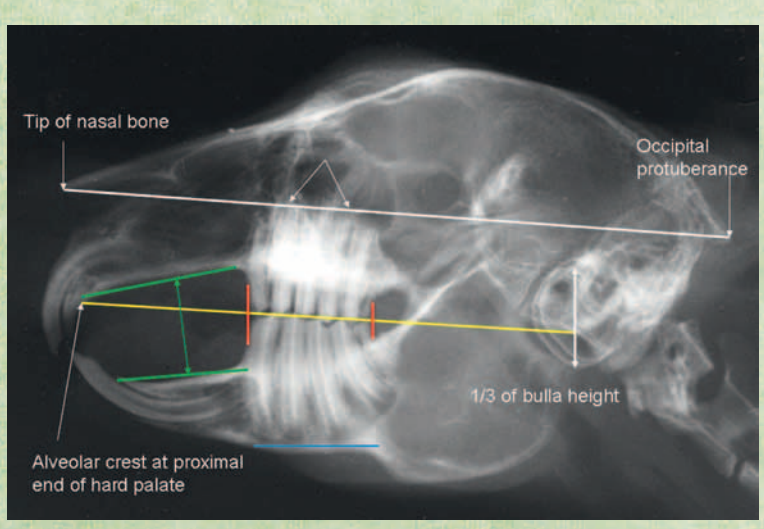

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Editorial

Practical everyday help to the busy European Practitioner

The challenge in our everyday working life is to provide medical care to companion animals based on the latest and best state of the art scientific information. Every case is individual and unique. That's why we never become bored in our profession. We acquire continuing education from our every day experience. Our knowledge grows with every case we see. Our university studies often seem very far away. A senior colleague once told me that getting the diploma/university degree can be likened to gaining a driving license. It gives us permission to improve our ability through our everyday work. Our increased knowledge not only results from our valuable personal experience. We must also keep our minds open to the newest advances in research. We must constantly synthesize and compare our personal experiences with state of the art knowledge gained from reading and other CE opportunities. We must reflect, discuss and stay critical. But who has the time to do this and at the same time work in a busy practice? We have to struggle through the huge mass of available information, selecting if possible, the best scientifically based practical information. Wouldn't it be nice if we had an independent veterinary expert who objectively selects and peer-reviews information for us? Well, we have this in the EJCAP! I am happy to rely on EJCAP for practical scientific guidance in my very busy practising vet's life. For me good examples of EJCAP's guidance were the recent papers on medical heart therapy and the evaluation of in-house blood analysis: basic, scientifically accurate, short, and practical! The knowledge that in the region of 30.000 companion animal practitioners all over Europe may well be gaining the same benefit as myself on this subjects after reading the articles gives me a good feeling of a strong Europe wide veterinary community. Coming as I do from Luxembourg, one of the smallest countries in Europe without its own specific national veterinary scientific journal, I welcome very much the ability to stay well informed on topics that are important to European Veterinarians with the help of FECAVA and EJCAP.
This vet-community will become even stronger when we can interact in the near future on our new FECAVA-internet-platform!

Katia Di Nicolo FECAVA Director, Luxembourg

FECAVA NEWS

Simon Orr, FECAVA Vice President reports:

Education

Veterinary Teaching Establishments

From the FVE Newsletter - December 2010

Evaluation: currently 48 out of 100 schools 'approved'

Professor László Fodor, president of the European Association of Establishments for Veterinary Education (EAEVE), guest speaker at the November General Assembly of the Union of European Veterinary Practitioners, gave an update on the evaluation of veterinary schools. The EAEVE now had 100 member schools in 34 countries. At the time of his presentation 48 of the 100 veterinary teaching establishments were approved. He explained the background of the evaluation system and the detailed functioning of an evaluation visit. In 2010, 19 establishments had been visited, and 11 were planned for 2011. Updating the standard operation procedures, the visiting expert list and an improved harmonisation of visits were among the goals during his mandate, Professor Fodor added.

Legislation

From the FVE Newsletter – December 2010

Illegal puppy trade now a criminal offence in Italy

The illegal trade of pets is now an officially recognised crime under the Italian Legal System. Three to 12 months' imprisonment and a €3,000 to €15,000 fine can be expected by anyone who repeatedly or as an organised activity introduces, sells or buys dogs or cats without identification (microchip or tattoo), and without the required health certificate and/or passport. Individual buyers and single offenders will also be pursued under the Illegal Introduction of Pet Animals. The penalty varies from €100 to €1000 for every dog or cat introduced in Italy without identification, and from €500 to €1000 for every dog or cat carried or sold without the required Health Certificate and/or the European Pet Passport. In both cases, the penalty will be raised if the pets are under 12 weeks of age or come from areas with restrictive veterinary measures.

Callisto project

The "CALLISTO" project proposal (Companion animals multisectorial interprofessional interdisciplinary strategic think tank on zoonoses) was finally submitted to the European Commission Directorate General for Research & Innovation at the end of January. The aim of the project is to identify knowledge and technology gaps in the management of the most important zoonoses transmitted by companion animals as well as to propose targeted actions that contribute to reduce the risk for infectious disease outbreaks in humans and food producing animals associated with keeping companion animals.

We are grateful to FVE for supplying this report

PSAVA appoints new Director to FECAVA

Dr. Blimke is the next President of PSAVA (Poland) and our new FECAVA Director.

Animal welfare

From the FVE Newsletter – December 2010

EU-wide identification & registration of pets "feasible and necessary"

A joint statement on identification and registration of companion animals in the European Union was released on 12 November 2010 by representatives of National, EU and International organisations working on databases for companion animals (http://www.carodog.eu/)

The signatories stressed that *"identification, registration and traceability*

are essential tools to promote the responsible ownership of companion animals" and that a compatible system of data management is *"feasible and necessary"*. They call for the establishment of a Europe-wide registration of companion animals. Mandatory identification, registration and traceability would not only support minimising the risk of zoonoses and constitute an important aspect of One Health, but would also enable efficient reuniting of pets and owners. The signatories of the statement agreed that this process, rather than leading to increased bureaucracy and costs, would actually simplify many procedures and save taxpayers' money at the local and national level, facilitating the reunion of lost pets with their families. European-wide compatible systems of data management should be further developed, and established. Veterinarians should play a key role giving a professional approach to identification and registration, education of the public and promotion of this message. From January 2010, CAROdog (Companion Animal Responsible Ownership – Dog) will issue a monthly newsletter and hold regular webinars.

Companion animals "to be included in AW Action Plan"

From the FVE Newsletter – December 2010

"An effective and reliable system of dog registration is crucial for successful animal health and welfare management, not only to reunite stray dogs with their owners, but also to help prevent illegal puppy trading and to promote responsible ownership". So said Christophe Buhot, FVE vice president, capturing the opinion of those present at the conference *"Responsible Dog Ownership in Europe"* held in Brussels on the 4th and 5th October 2010. The conference, organised by CAROdog (Companion Animal Responsible Ownership – Dog), an initiative of "Four Paws" and Istituto G. Caporale, attracted 100 participants from over 25 countries. They represented European and National institutions, International Organisations, NGOs, private sector and Veterinary organisations. Regarding canine overpopulation, there was also a broad consensus that this should be addressed by the prevention of unwanted puppies, control of stray dogs and responsible dog ownership. The conference also called for institutional action, urging the Council of the EU to recognise the importance of companion animal welfare as a relevant issue for EU legislation, while the EU Commission should include references to companion animals in the second Animal Welfare Action Plan. Areas for action, according to the conference conclusions, include the regulation and licensing of breeding and trade, EU-wide compatible identification and registration. *"Without registration, identification is of little value and traceability is an important tool to fight diseases and to protect welfare."*, Christophe Buhot stressed, calling for a mandatory pet identification, registration in a national database and the transmission of ID numbers to a central European database. FVE is an active project partner of CAROdog.

European Board for Veterinary Professional Development

From Andrew Byrne FECAVA Senior Vice President

The last General Assembly/Council meetings of the Federation of Veterinarians of Europe (FVE), the Union of European Veterinary Practitioners (UEVP) and FECAVA approved the formation of an interim European Board for Veterinary Professional Development (EBVPD). The function of this board is to oversee the introduction of the Acknowledged Veterinarian programmes and to explore harmonization of CPD points in Europe. This board will comprise a representative from the main veterinary organisations i.e. FVE, UEVP, FECAVA, the European Board of Veterinary Specialisation (EBVS), the European Association of Establishments for Veterinary Education (EAEVE) and the statutory bodies. The interim board hopes to convene in the spring of this year and will establish its statutes and objectives.

The FECAVA Working Group on Postgraduate Education has begun working on developing a structure for the Acknowledged Companion Animal Veterinarian programme and has begun a consultation process with its member associations.

FECAVA will report regularly on the progress on this education initiative.

FECAVA Working Group on Hygiene and the Use of Antimicrobials in Veterinary Practice

From Alexandra Vilén
Chair of Working Group on Hygiene and the Use of Antimicrobials in Veterinary Practice

2010 was certainly an exciting year for this working group. Not only did the group release a poster with hygiene guidelines but also several of the group members have been giving lectures throughout Europe on the topic of veterinary hygiene as well as on the use of antimicrobials. The Group was instrumental in organising the FECAVA Symposium 2010 'Hygiene and Antimicrobial Resistance' which was held during the FECAVA Eurocongress held in Geneva last June. Papers from the symposium are published in full in this issue.

The interest from different organisations and companies wishing to become associate members of this group is growing and clearly shows the importance of this kind of work. The group consists not only of FECAVA directors but also external experts from different fields and this creates a dynamic and skilled group. So far, the main task has been to provide hygiene guidelines for veterinary practitioners in Europe.

The FECAVA hygiene poster (see p 86) that was released during 2010 can be downloaded for free from the FECAVA website http://www.fecava.org/files/981.pdf

There are several FECAVA member associations currently working on translations of the poster to provide their

members with the information in their own language. The Greek association is the first one to have finished this task but more will be available during the first months of 2011. If you wish your association to translate the poster please contact the Director of your national association.

The future aim for the working group is to continue the work with hygiene routines and the responsible use of antimicrobials. We want to improve the European veterinarian's awareness of these matters as well as provide tools to implement a healthy approach for practitioners.

Vet-2011: the future of veterinary medicine

"Happy birthday and my very best wishes for the next 250 years". With these words Mr John Dalli, EU Commissioner for "health and consumers" formally opened the celebration of World Veterinary Year Vet-2011.

The opening ceremony took place at the historical site of Versailles, the former residence of the French kings. It was here that 250 years ago Mr Claude Bourgelat managed to convince King Louis XV to set up the first veterinary school: a landmark in the development of veterinary education and the veterinary profession. Claude Bourgelat also promoted comparative pathobiology, the foundation of our current One Health concept.

Many distinguished speakers, including WVA President Tjeerd Jorna, OIE Director General Bernard Vallat, WHO General Director Margaret Chan, and FAO Director General Jacques Diouf took the floor and highlighted the importance of veterinary medicine for the health and welfare of animals and people. Also UNESCO and IUCN (the international Union for Conservation of Nature) emphasized the role they see for the veterinary profession.

Although very important, the support of these influential people alone will not be enough to ensure the future of the veterinary medicine. Crucial will be how much we will be able to convey the message to the public at large and to gain and keep their support. Vet-2011 offers a unique opportunity to communicate about the importance of ensuring the health and welfare of animals and people.

Interesting therefore is the launch of 6 video clips about the different aspects of the veterinary profession.
http://ec.europa.eu/dgs/health_consumer/information_sources/world_vet_year_2011_en.htm
Another funny video clip announces a photo competition organised by the European Commission.
http://www.youtube.com/watch?v=pbGVq-wTPQc

At this moment Vet-2011 comprises 1040 corresponding members in over 119 countries. In 42 countries all Vet-2011 initiatives are coordinated by a national Vet 2011 committee. Don't miss it. A very informative website provides all kinds of information related to Vet 2011 http://www.vet2011.org. Not surprisingly the number of visitors has to the Vet-2011 web site has gone up enormously over the last few months.

We are grateful to FVE for supplying this report.

European Pet Night 2011

From Monique Megens
Honorary Secretary FECAVA

As a partner association, FECAVA joined the European Pet Night for the second year. EU decision makers, animal welfare non-governmental organisations, the animal health industry, veterinarians and pet owners gathered for this event in Brussels' Bibliothèque Solvay to highlight the importance of pets. This year tribute was paid to the many ways in which animals assist humans and the work of dogs trained to rescue survivors after natural disasters was showcased.

Member of Parliament Dr. Schnellhardt, who himself is a veterinarian, welcomed the November 2010 Council of the European Union conclusions on the welfare of cats and dogs: "*For the first time, the Member States have recognised the need to introduce more guarantees for the welfare of our four-footed and feathered friends. I wholeheartedly welcome this development and hope that the many organisations participating in tonight's event see it as recognition of their diligent work delivered year in, year out*".

Member of Parliament I.G. Perez said "*The fact that the Council now has called for promotional and educational campaigns for responsible pet ownership is a very important step forward in raising public awareness of these matters.*"

The event was well organised by IFAH-Europe, the representative body of manufacturers of veterinary medicines, vaccines and other animal health products. At the reception afterwards special interest was shown in FECAVA's documents on the economic importance of companion animals and the Health benefits (socioeconomic value) of companion animals. It was an excellent opportunity for FECAVA to have direct exchanges with partner organisations and EU decision makers.

WSAVA Enters into Agreement With Kenes as Core Professional Congress Organizer

During the Sao Paulo 2009 WSAVA Assembly Board meeting, the Assembly members voted to revise the method of bidding for and hosting the annual WSAVA Congresses. The result was that WSAVA has entered into a partnership agreement with Kenes, one of the largest and Internationally diverse PCOs, following an extensive PCO review process. The agreement will see Kenes centrally administer WSAVA Congresses, beginning in 2014, in partnership with the local host bidding association, thereby building on and strengthening the reputation of WSAVA Congresses as culturally unique with cutting-edge scientific sessions. The bidding process will also follow a set region-to-region approach, beginning with Capetown, South Africa (Europe and Africa) in 2014, Asia and Oceania in 2015, and the Americas (South and North) in 2016.

WSAVA One Health Initiative

The WSAVA One Health Committee (OHC) held its inaugural meeting over two days preceding the NAVC meeting in Orlando, Florida in January 2011. The OHC was launched officially at the 2010 Geneva WSAVA/FECAVA Congress and the core members of the committee are:
M.J. Day [Chair; University of Bristol, UK]
J. Kirpensteijn [WSAVA Board; Utrecht University, the Netherlands]
A. Thiermann [OIE; Paris, France]
C. Rubin [CDC; Atlanta, USA]
M. Lappin [Colorado State University, USA)
S. Cleaveland [Glasgow University, UK]
C. Khanna [NIH; Maryland, USA]
C. Palatnik-de-Sousa [Federal University of Rio de Janeiro, Brazil]
U. Karkare [Practitioner Representative; Mumbai, India]

At the January meeting, the OHC considered that there were three key areas of One Health with which it should engage: (1) the human-companion animal bond, (2) comparative and translational medicine and (3) zoonotic infectious disease.

The initial focus of the committee would be in the area of zoonotic infectious diseases. There are already many excellent initiatives related to key zoonotic diseases (in particular rabies) and the committee would endorse and support such initiatives.

The WSAVA OHC has already had one review paper published (*Veterinary Record* 2010 **167**: 847) and has another in press (*Parasites and Vectors*). The committee will be presenting two papers at the 1st International One Health Conference in Melbourne, Australia in February 2011, ensuring that companion animals are strongly represented in this first truly global discussion of One Health.

The work of the WSAVA OHC is made possible by a consortium of industry sponsors who have contributed to the WSAVA Foundation specifically to fund this project. The OHC is grateful to our sponsors who include at the time of writing (in alphabetical order): Bayer Animal Health, Hills Pet Nutrition, Intervet-Schering Plough Animal Health, Merial, Nestlé Purina, Novartis Animal Health, Pfizer Animal Health, Waltham and the WSAVA itself.

Save the dates!

WSAVA 2011 Jeju World Congress, October 14-17, 2011 in Jeju, Korea. For more information, including scientific programme and registration, please visit the Congress website at http://www.wsava2011.com/

Future Congresses:
- Birmingham, England April 12-15, 2012 (with FECAVA)
- Christchurch, New Zealand March 6-9, 2013
- Capetown, South Africa - Date to be confirmed

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Members of the WSAVA One Health Committee at the inaugural meeting: (L-R): J. Kirpensteijn, M. Lappin, M. J. Day [Chair], C. Rubin, C. Palatnik-de-Sousa, C. Khanna.

UEVP NEWS

Report on the general assembly of the Union of European Veterinary Practitioners

Our last meeting took place in Brussels on 11th November 2010 and was well attended by the twenty five member countries that comprise the UEVP.

Our aim is to represent the interests of veterinary practitioners throughout Europe in whatever capacity that they work. This means good cooperation with the other sections of the Federation of Veterinarians in Europe – EVERI which represents education, research and industry; UEVH who represent hygienists and public health; EASVO which is the section representing state officers.

As usual we had a full agenda which included a joint session with EVERI on educational issues.

We received a presentation by Professor Laszlo Fodor the Dean of Budapest Veterinary School, who is the current President of EAEVE, on the working and current situation of the inspection of veterinary schools throughout Europe. This is based on Directive 2005/36/EC (which is under review) and is a voluntary inspection but EAEVE and FVE are trying to be recognised by ENQA in order to give the inspection a legal standing.

We also heard the interim results on the questionnaire, designed by FECAVA, on the availability of post-graduate qualifications in Europe, which was disseminated after our last GA. This shows that only one third of the 19 responding countries had a formal post graduate qualification available to practitioners.

Our aim is to encourage the design of a European post graduate qualification referred to as the 'acknowledged vet' and to quantify CPD so that it becomes a known quality and is transferrable between countries.

A session on practice economics will now be a regular feature at our GA. Some practice turnover figures were given from France, UK, Netherlands and Germany. It would appear that all countries are seeing a reduction in income in real terms with Germany being little affected whilst horse work in the Netherlands and large animal work in France being the worst affected. There were signs that there was a slight recovery in 2010 on figures from 2009 but less than the rate of inflation.

A questionnaire has been disseminated asking our member countries what are the main problems facing veterinary practice. It is important for our organisation to recognise common problems, such as the working time directive and availability of medicines, in order to place them in perspective and to assist in findings solutions.

We had a presentation by René Beaumont, a Senator from Bourgogne in rural France, on the state of veterinary work in France. Although he reported that 30% of registered veterinary surgeons were still working in rural regions this is declining and is of concern. They are trying to encourage younger members of the profession to work in rural areas by giving them financial incentives such as higher fees and an improved interpretation of the veterinary act.

There were several other issues reported on Medicines, Animal Welfare and radiological protection.

All presentations are available on the UEVP website.

Andrew Robinson
UEVP General Secretary

REPRINT PAPER (CH)

Stabilisation of the emergency patient part I: Airway and breathing

Nadja Sigrist[(1)]

INTRODUCTION

Patients with respiratory distress are, regardless of the underlying cause, emergency patients and the initial approach to these patients determines prognosis and survival. Animals with respiratory distress are stressed which makes most diagnostic procedures impossible or counter-productive. By localising the respiratory problem using the initial clinical exam of the animal, the clinician can narrow down the causes of respiratory distress. Looking at the type of breathing, type of dyspnoea and using auscultation findings and information from the history, the problem can be localised, limiting possible differential diagnoses. This allows institution of not only supportive measures such as oxygen supplementation, stress-free handling or analgesia but also a more specific therapy of the problem causing respiratory distress. The stabilised animal can then undergo further diagnostic procedures and receive specific treatment.

Key words: respiratory distress, emergency stabilisation, thoracocentesis, oxygen

This paper originally appeared in:
*Kleintierpraxis** **55**, 2, (2010), 85-96 #

Introduction

The rapid identification of life-threatening emergency conditions in small animals followed by immediate stabilisation can be lifesaving. Stabilisation is concentrated on the maintenance of respiration and circulation. The acronym ABC – Airway-Breathing-Circulation – is used in both veterinary and human medicine for the resuscitation of patients with cardiopulmonary arrest [Mitka 2003]. Compliance to this order of stabilisation is recommended for all emergency patients. The prompt identification of life threatening conditions requires a routine approach and a so-called "horizontal case management": medical history, short physical examination, initial diagnostic tests and treatment modalities are evaluated and instituted not consecutively, but concurrently to allow for immediate stabilization of the patient [Aldrich 2005]. The measures, however, focus primarily on the stabilisation of the patient and not on the complete diagnosis and specific treatment (unless the diagnosis is obvious). The following review article therefore primarily focuses on measures to stabilize the emergency patient with respiratory distress.

Respiratory distress or dyspnoea is a condition of lack of air, which a sick person feels at rest or during mild exercise [American Thoracic Society, 1999]. Although the perception of a feeling of breathlessness cannot be proven in animals, one must assume that animals feel similar to humans. In veterinary medicine, dyspnoea is defined as the patient showing clinical signs of respiratory distress that are associated with a feeling of breathlessness in people. The clinical signs in animals as well as humans include tachypnoea, orthopnoea, open mouth breathing, increased abdominal breathing effort, abnormal breathing patterns or chest movements, laboured breathing and / or cyanosis [American Thoracic Society, 1999]. Respiratory distress may result from hypoxia, hypoventilation or breathing associated with an increased effort, or pain. A simple and effective means to assess the respiration of the veterinary patient, is the imitation of the respiration of the animal by the

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* Presented by SVK/ASMPA (Switzerland)

veterinarian himself. In most cases, after a very short time, it is clear whether the animal's breathing is normal or abnormal and whether it is associated with dyspnoea or not.

Signalment

Respiratory distress is not associated with species, breed or age. These parameters can though be helpful to include or exclude certain differential diagnoses. Paediatric animals and small mammals show physiologically an increased respiratory rate.

History

The duration of symptoms and their progression can provide information regarding diagnosis and treatment. Information such as progress and details of any previous therapy (self-treatment by the owner or therapy initiated by another veterinarian), pre-existing disease or related symptoms (heart disease), and the possibility of a trauma must be obtained from the owner. Questions regarding the previous history are important even with severe difficulty in breathing, because this information may be useful for emergency treatment [Silverstein and Drobatz, 2005]. A short history can be obtained while the patient's breathing is observed and the animal is being supported with oxygen.
Following primary stabilisation of the patient, a complete history regarding vaccination and deworming status, stays abroad, frequency and nature of cough, etc. are important for further diagnostic examinations and treatment. A cough can be dry or moist and the latter is often confused with gagging by the owner. Nocturnal cough is more likely associated with a disease of the lower respiratory tract (accumulation of fluid while lying), while upper airway disease can be expected with a history of a cough associated with excitement or pull on the collar. The broad direction of further diagnostic exams can often be defined on the basis of the prevailing cardinal symptoms.

Primary survey

The initial physical examination of the emergency patient should give an overview of the function of vital organs including the lung, the cardiovascular and the central nervous systems. The evaluation of the respiratory tract includes the evaluation of respiratory rate, respiratory type, presence and type of dyspnoea, lung and heart auscultation with concurrent pulse quality assessment, and identification of obvious external injuries to the trachea and thorax [Snyder, 2003; Tseng and Waddell, 2000]. Patients with respiratory distress must be supplemented with oxygen even during the short primary survey and should be examined in as stress-free manner as possible [Tseng and Waddell, 2000; Rozanski and Chan, 2005]. The animals should be allowed to adopt the preferred position themselves.
The type of dyspnoea may be inspiratory, expiratory or mixed. The type of respiration may be fast and shallow, with increased effort, or asynchronous, and provides the most useful information for the anatomical localization of the problem. With asynchronous breathing, the chest and abdominal wall movement during inspiration is not synchronized. The initial clinical survey should also assess the posture of the animal. An extended neck or abducted elbows are signs of severe respiratory distress. Cyanotic mucous membranes are associated with a massive increase in deoxygenated haemoglobin (> 3-5 g / dl). A clinically apparent cyanosis is therefore a sign of significant hypoxaemia although a normal mucous membrane colour does not exclude hypoxemia, as the presence of cyanosis is haemoglobin dependent [Petrie 2005]. Auscultation results will help to further localize the problem. All lung fields as well as the heart should be thoroughly auscultated. Increased, decreased, missing or moist lung sounds may be identified.
If the patient is stable enough, palpation of the cervical trachea, laryngeal inspection, chest percussion, abdominal palpation and the evaluation of mucosal colour and moisture may also provide important clues to the cause of dyspnoea. Obvious injuries are usually identified without palpation depending on the length and condition of the fur, smaller penetrating chest injuries, or emphysema are only evident on palpation of the chest wall. Precipitation of cough by palpation of the trachea and / or the larynx can locate the problem in this region. Results from abdominal palpation, such as an "empty abdomen" due to a shift of abdominal organs into the thoracic cavity with diaphragmatic hernia, ascites or a space-occupying lesion, which lead to impaired ventilation, should also be included in the problem-oriented diagnostic workup of patients with respiratory distress.

Emergency stabilisation

Oxygen supplementation, stress free handling of the patient and adequate analgesia for painful patients should be instituted prior to the clinical examination in any animal with respiratory distress. Specific, acute emergency measures such as a tracheostomy, thoracocentesis or medical stabilization options are discussed under the appropriate localization or differential diagnoses, respectively.
Oxygen is the treatment of choice for all patients with respiratory distress as all possible causes respond to oxygen supplementation to some degree [Camps-Palau, 1999]. Initially, oxygen may be applied with 5-15 l / min rate by mask or flow-by (Fig. 1). If an oxygen cage is available, small pets can be transferred directly from the transport basket into the oxygen

Figure 1: Oxygen supplementation by flow-by

Drug	Brand name	Dosage	Effect
Acepromazine	Prequilan®, Fatro S.p.A., I	0.005 mg/kg i. v. / i. m.	Sedation
Beclomethasone	Beconasol®, GlaxoSmithKline, GB	1 puff locally	Decreases swelling
Butorphanol	Morphasol®, Dr. E. Graeub AG, CH Alvegesic®, Virbac, CH others	0.2 mg/kg i. v. / i. m. / s. c.	Analgesia (40 minutes), sedation (2-4 hours)
Dexamethasone	various	0.25 mg/kg i. v.	Anti-inflammatory, decreases swelling
Fentanyl	various	2–5 µg/kg i. v. / i. m.	Analgesia (20 minutes)
Fluticasone	Axotide®, GlaxoSmithKline, GB others	44–220 ug inhalation BID	Steroid, decreases swelling
Furosemide	various	1–2 mg/kg kg i. v. / i. m. / s. c.	Diuresis → decreases hydrostatic pressure
Methadone	various	0.1-0.2 mg/kg kg i. v. / i. m.	Analgesia (1-2 hours)
Salbutamol	Ventolin®, GlaxoSmithKline, GB	108 ug (1 puff) by inhalation as often as required	Selective local bronchodilator
Terbutaline	Bricanyl®, AstraZeneca, CH	0.01 mg/kg i.m/s.c every 4 hours	Selective bronchodilator
Theophylline	Euphillin®, Nicomed Pharma AG, CH	4 mg/kg slowly i. v. / i. m.	Bronchodilator (non-selective)

Table 1: Emergency drugs for patient with respiratory distress

cage [Mandell, 2004]. The primary examination including palpation and auscultation of the thorax may be conducted with the animal in the oxygen cage. Subsequently, it is more practical to place a nasal oxygen tube or apply oxygen by an oxygen tent made out of a half-covered e-collar [Tseng and Drobatz, 2004]. The oxygen flow is 100 ml / kg / min for the nasal oxygen tube (1-2 l / min for cats and small dogs, 2-3 l / min for medium dogs and 4-6 l / min for large dogs) [Fitzpatrick and Crowe, 1986] and 200 ml / kg / min for the oxygen tent (2-8 l / min) [Crowe, 1995]. Stress leads to an additional increase in oxygen consumption and should be avoided at all costs. Animals should be able to determine their position themselves and should not be forced in a lateral or supine position, or be restrained [Lee and Drobatz, 2004].

With evidence for an upper airway obstruction, such as inspiratory dyspnoea, stridor or respiratory movements without an obvious exchange of air, the airways must be secured [Lee and Drobatz, 2004].

Pain can intensify or cause the symptoms of respiratory distress (e.g., rib fractures, sternal luxation). Trauma patients especially should be promptly and adequately covered with analgesics [Sigrist, 2004]. Opioids such as methadone, butorphanol, or fentanyl are preferred, as these are short effective, titratable and reversible (Table 1). All opioids cause some degree of respiratory depression, which, however, at low doses has no effect clinically [Campbell *et al.*, 2003]. Butorphanol leads to less inhibition of respiration, but has also a less potent analgesic effect and is therefore more likely indicated for sedation [Plumb, 2004]. If sedation is required in addition to an analgesic effect, the above-mentioned opioids can be combined with low-dose acepromazine (0,005 mg/kg). However, any sedation may lead to further respiratory depression and failure of compensatory mechanisms [Perkowski, 2004]. In this case, intubation and ventilation are mandatory and the appropriate equipment should have been prepared prior to sedation: cuffed endotracheal tubes in various sizes, stylet, functional laryngoscope, gauze, syringe to inflate the cuff, securing strap and possibly lidocaine spray. Animals with agonal breathing must immediately be intubated and mechanically ventilated [Cole, 2002].

To perform mechanical ventilation, an airway must be established. The pharynx is cleared of any blood, saliva, or gastric contents and obvious foreign bodies are removed. Long surgical clamps are especially helpful in doing so. Animals with agonal breathing may bite uncontrollably and the throat should never be attempted to be cleared using the fingers. If orotracheal intubation is not possible immediately, an emergency tracheotomy must be performed. If the airways are clear, the animal is intubated. The choice of a perfectly sized endotracheal tube is less important than immediate intubation, as the placement of a too small tube is less problematic than needlessly losing time searching for the perfect tube. However, the endotracheal tube should be cuffed and the cuff must be inflated after intubation in order to allow mechanical ventilation. Intubation should preferably be carried out under visual control to ensure an endotracheal intubation. After intubation, the animal is ventilated 2-3 times (using an Ambu bag or by mouth-to-tube ventilation) and is then - if not already in place – connected to an Ambu bag or an anaesthetic machine supplemented with 100% oxygen. The recommended respiratory rate is 10-20 breaths per minute. Ventilation should achieve normal chest wall excursions, without having to apply too much pressure. If orotracheal intubation has not been performed under direct vision, correct tube positioning has to be confirmed by auscultation of lung sounds bilaterally.

If orotracheal intubation is delayed for any reason, the animal can be ventilated mouth-to-nose (with closed mouth). The oesophagus is compressed by grasping the anterior neck caudal to the larynx with one hand, ensuring that air applied by ventilation does not enter the stomach. However, this method is not a substitute for intubation, as some of the air is always lost and the oxygen concentration of the air is less than 20%. After securing the airways and instituting ventilation, cardiac arrest is identified by assessing the heart beat and pulse. In the absence of a femoral pulse and a lack of heart sounds, external cardiac compressions are started. External cardiac compressions are –in contrast to humans- performed in right lateral recumbency.
If the animal shows severe respiratory distress or cyanosis despite oxygen supplementation, analgesia, and initial stabilization measures according to the localization of dyspnoea, the animal should be intubated and ventilated before respiratory and cardiac arrest occurs [King and Hendricks, 1994; Campbell and King, 2000]. Orotracheal intubation requires an unconscious or anaesthetized patient. The anaesthetic protocol chosen should include drugs that enable rapid intubation, such as propofol or etomidate. The dosage is chosen to effect. Whenever possible, intravenous access should therefore be achieved after the initial stabilization. An iv access will enable administration of drugs such as analgesics or sedatives and allows induction of anaesthesia followed by intubation and ventilation in case of worsening breathing [Lee and Drobatz, 2004]. Again, the goal should be that the animal is not stressed when placing an intravenous catheter and to provide supplemental oxygen during the procedure.
Intubation and ventilation with 100% oxygen have the great advantage that ventilation is maximally controlled and the animal can be monitored, so that further investigations can be carried out without stressing the animal.

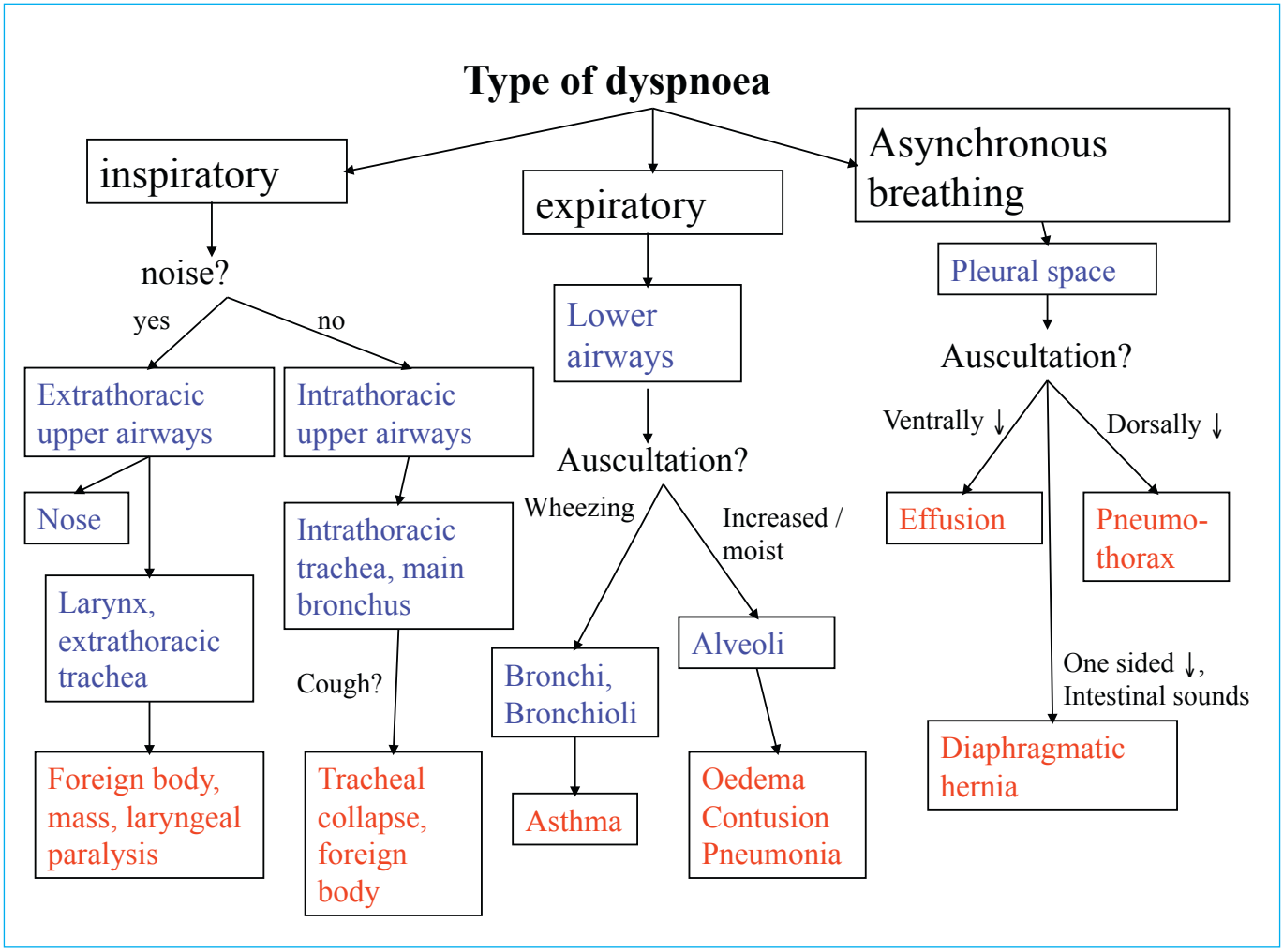
Localisation of the respiratory problem and specific therapy

Based on the type of respiration, auscultation results, inspection and palpation of the thorax, the respiratory problem can in most cases be anatomically localized [Tseng and Waddell, 2000]. The list of differential diagnoses can then be reduced to a few diseases (Figure 2). Based on the localization more specific stabilization measures can also be initiated (Table 2).

Upper respiratory tract

The upper respiratory tract includes the mouth, nose, pharynx and larynx, trachea, and the main bronchi [Lee and Drobatz, 2004]. Animals with upper airway disease show an inspiratory dyspnoea with a prolonged inspiratory phase. Stressed, animals may also show panting or rapid shallow breathing [Tseng and

Figure 2: Localization of the respiratory problem



Localization	Type of respiration	Auscultation results	Differential diagnoses	Emergency treatment
Extrathoracic upper airways	Inspiratory dyspnoea	Stridor/stertor	FB, swelling, laryngeal paralysis, tracheal collapse, brachycephalic syndrome	O_2 Sedation +/- local steroids +/- Intubation/ tracheotomy
Intrathoracic upper airways (trachea, main bronchus)	Inspiratory dyspnoea	Cough, stridor heard only with stethoscope	FB, mass, tracheal collapse, -rupture with swelling	O_2 +/- sedation Intubation
Lower airways (bronchi, bronchioli)	Expiratory dyspnoea	Wheezing	Asthma, bronchopneumonia	O_2 Rest Bronchodilators Steroids
Pulmonary parenchyma	Mixed dyspnoea or shallow breathing	Increased lung sounds	Contusions, pneumonia, neoplasia, (oedema)	O_2 Analgesia +/- bronchodilators
Pulmonary parenchyma	Mixed dyspnoea, Prolonged expiration or shallow breathing	Moist lung sounds, +/- arrhythmias, heart murmur	Pulmonary oedema (cardiogenic / non-cardiogenic)	O_2 Rest +/- butorphanol Furosemide +/- bronchodilators
Plerual space	Asynchronous breathing or shallow breathing	Decreased dorsally / ventrally	Pneumothorax, Pleural effusion	O_2 Analgesie
		Decreased asymmetrically, intestinal sounds	Diaphragmatic hernia, mediastinal mass	O_2 Thoracocentesis Analgesia
Chest wall	Fast shallow breathing Abnormal chest wall movements	normal	Rib fractures, flail chest, muscle torsion	O_2 Analgesia Chest wall stabilisation FB: Foreign body

Table 2: Localization, differential diagnoses and emergency treatment

Waddell, 2000; Holt 2004]. With a loud inspiratory breath sound (stridor or stertor), the cause is more likely found in the extrathoracic upper respiratory tract, while expiratory sounds are more frequently associated with intrathoracic upper airway problems [Herrtage and White, 2000; Silverstein and Drobatz, 2005]. Stertor represents a low-pitched snoring sound that arises primarily from obstructed diseases affecting the nose or nasopharynx. Respiratory stridor describes a higher pitched respiratory noise heard during inspiration that is associated with an extrathoracic obstruction affecting the larynx or trachea. By opening the mouth, the respiratory noise can be located in the nose or throat. Diseases of the nasopharynx also often lead to nasal discharge and / or swallowing abnormalities. Diseases of the trachea will lead to increased lung sounds or wheezing heard on auscultation [Koch *et al*., 2003; Payen *et al*, 2006], and coughing may also be a common symptom [Mason and Johnson, 2004].

Differential diagnoses of upper respiratory tract lesions are foreign bodies, masses, swelling, laryngeal paralysis, tracheal collapse, or the brachycephalic syndrome. A tentative diagnosis can often be made based on the breed: brachycephalic breeds are predisposed to respiratory distress associated with the brachycephalic obstructive syndrome [Koch *et al*., 2003], middle-aged to older large dogs (Huskies, Dalmatians, Rottweilers and Bull Terriers) for laryngeal paralysis [Gaber *et al*., 1985; Holt and Brockman, 2004; Silverstein and Drobatz, 2005] and small dogs, especially Yorkshire Terriers, for tracheal collapse [Mason and Johnson, 2004; Payen *et al*., 2006]. Nasal discharge or swallowing and choking have frequently been reported in conjunction with a foreign body [Juergens and Wrieg, 1991; Hackenbroich *et al*., 2008].

In addition to the emergency stabilisation, the specific treatment is adjusted to the individual situation. A sedation is especially useful in patients with inspiratory dyspnoea due to tracheal collapse, laryngeal paralysis and to prevent further swelling of the upper respiratory tract [Holt and Brockman, 2004]. Acepromazine alone (0,025 -0.05 mg / kg IM or IV) or in combination with butorphanol (butorphanol 0.2-0.4 mg / kg plus acepromazine 0.005-0.01 mg / kg) or diazepam (0.2-0.5 mg / kg) in combination with an opioid can be used as sedatives. The sedation not only leads to a decrease in oxygen consumption, but also reduces the laryngeal and tracheal collapse by reducing the inspiratory intrapleural pressure [Holt and Brockman, 2004]. All materials necessary for intubation and tracheotomy should be prepared before sedating an animal because sedation may result in severe cyanosis, respiratory distress, or even respiratory

arrest. Swelling of the upper respiratory tract can be treated locally and / or systemically using corticosteroids [Holt and Brockman, 2004]. Depending on the extent of the swelling local beclomethasone (Beconasol®, GlaxoSmithKline, UK) and / or systemic dexamethasone (0.25 mg / kg IV) have been shown to be effective. Hyperthermic animals should be actively cooled by wetting the fur with water or using a fan [Holt and Brockman, 2004].
If the animal shows severe respiratory distress and intubation is not possible, an emergency tracheotomy must be performed [Hedlund, 1994].

Emergency tracheotomy
An emergency tracheotomy differs from a surgical tracheostomy, because in the former case the animal is not anaesthetized and ventilated and therefore a fast access to the trachea is mandatory. If possible, the animal is placed in a supine position with the neck stretched and positioned as symmetrical as possible. After a quick clip and wash a long 3-5 cm longitudinal incision is placed over the midline of the ventral neck caudal to the palpable laryngeal cartilages. The subcutaneous tissue and muscles above the trachea are separated by blunt dissection and the trachea is exposed. This is, depending on breed, nutritional status and mentation of the animal, the hardest part. After exposing the trachea, a transverse incision of approximately 40 - 50% of the tracheal circumference is placed between the third and fourth or fourth and fifth tracheal ring, and the animal is immediately intubated using an endotracheal or tracheotomy tube, and mechanical ventilation is started with supplemented oxygen. Subsequently, stay sutures are placed both at the cranial and caudal tracheal incision in order to facilitate change of the tracheotomy tube. The tracheal tube is fixed with a tie around the neck of the animal and should never be attached with sutures. The wound is covered with a sterile gauze. Generally, a bandage is not placed as obstruction (by thickened secretions), or loss of the tube, require a rapid access to the trachea.

Lower respiratory tract
The lower respiratory tract consists of the bronchi, bronchioles and alveoli. Animals with lower airway disease often show expiratory dyspnoea [Mandell, 2004], which appears particularly pronounced in cats with asthma [Corcoran *et al*., 1995]. On auscultation, wheezing and both inspiratory and expiratory increased breath sounds can be detected. Cats with asthma often have a history of coughing [Corcoran *et al*., 1995; Dye *et al*., 1996]. Moist lung sounds are a sign of bronchial or alveolar fluid accumulation, which may be associated with pulmonary haemorrhage (look for further evidence for a trauma) or pulmonary oedema (rule out arrhythmias and a heart murmur).
Differential diagnoses of lower respiratory tract lesions are asthma, chronic bronchitis, pulmonary oedema, pulmonary haemorrhage, and COPD (very rare).
Feline asthma is the primary differential diagnosis in a cat with severe expiratory dyspnoea (and possibly wheezing at auscultation) in the absence of symptoms indicating a trauma (scuffed nails, fractures, wounds), or evidence of heart disease (arrhythmias, heart murmur, hypothermia). In the dog with expiratory dyspnoea heart disease and trauma should be ruled out.
The emergency treatment of animals with lower respiratory tract disease includes the administration of oxygen, stress-free handling, rest in a quiet environment, and the administration of bronchodilators and steroids if indicated. Terbutaline (Bricanyl®) is a selective bronchodilator, and preferable to methylxanthine derivatives, such as theophylline. Terbutaline (0.01 mg / kg IM or SC every 4-8 hours) can be used as an emergency drug in cats with expiratory dyspnoea [Bay and Johnson, 2004]. Theophylline (Euphillin®, Nicomedes Pharma AG, Switzerland) at a dose of 4 mg / kg slowly IV is an alternative. An increase in heart rate may occur as a side effect of bronchodilators, the indication in animals with tachycardia is therefore restricted. Cats, which respond to bronchodilators and oxygen, show a decrease in respiratory rate within 30-45 minutes [Bay and Johnson, 2004]. If no effect is seen, terbutaline can be repeated and a corticosteroid at anti-inflammatory dosage (0.25-1 mg / kg dexamethasone) can be administered IV [Dhupa and Byers, 2004].
Both bronchodilators and corticosteroids may also be administered locally by inhalation [Padrid, 1992]. A useful system is on the market (AeroKat®, Trudell Medical International, USA). The dosage of salbutamol (Ventolin®, GlaxoSmithKline, UK), a β-2 adrenergic agonist, is 108 µg (1 puff), while that of fluticasone (Axotide®, GlaxoSmithKline, UK), a corticosteroid for inhalation, is 44-220 µg [Dhupa and Byers, 2005].

Lung parenchyma
This includes the lung interstitium, the vascular supply, and parts of the alveoli. Animals with parenchymal lung disease show either a mixed dyspnoea with frequently an expiratory component or a very fast and shallow breathing [Silverstein and Drobatz, 2005]. Increased or wet lung sounds can be heard on auscultation [Thayer and Robinson, 1984; Kogan *et al*., 2008].
Differential diagnoses include lung contusions, infectious pneumonia, aspiration pneumonia and cardiogenic or non-cardiogenic pulmonary oedema [Nelson and Sellon, 2005]. Pulmonary contusions are the primary differential diagnosis in the trauma patient [Powell *et al*., 1999]. Animals with a heart murmur or arrhythmias are primarily classified and treated as cardiac disease-related dyspnoea patients. Cats with cardiogenic pulmonary oedema often show signs of shock and hypothermia [Shoemaker, 1999].
In younger dogs, which present with cough and tachypnea / respiratory distress and expiratory dyspnoea or shallow breathing, "newer" diseases such as Angiostrongylus pneumonia [Bolt *et al*., 1994], distemper, or leptospirosis associated pulmonary haemorrhage [Schweighauser and Francey, 2008] should be ruled out.
The treatment of parenchymal lung disease include the continuous supplementation of oxygen, antibiotic treatment for bacterial pneumonia, and supportive measures such as analgesia, gastric protection, anti-emetics (aspiration pneumonia) and bronchodilators [Lee and Drobatz, 2004]. Less often, ventilation therapy is required [Campbell and King, 2000].
When moist lung sounds without clinical evidence of hypovolemia or dehydration are identified, a single dose of furosemide (1-2

mg / kg IV) can be administered [Mandell, 2004]. If there is a reasonable suspicion of cardiogenic pulmonary oedema, and no response to the initial dose of furosemide, furosemide (1 mg / kg) may be repeated at intervals of 30 minutes up to a maximum dose of 4-8 mg / kg. Furosemide reduces the intrapulmonary hydrostatic pressure by diuresis and has a vasodilating effect in the lung [Lundergan *et al.*, 1988]. This leads to a decreased fluid shift into the lungs and increased reabsorption of water from the pulmonary interstitial space. Furosemide has no significant effect on non-cardiogenic pulmonary oedema which is caused by increased permeability [Molloy *et al.*, 1985].

Methylxanthine bronchodilators such as theophylline also increase tracheal mucocilliary transport capacity, inhibit mast cell degranulation and increase diaphragmatic contraction [Boothe, 2000]. Due to the positive chronotropic and inotropic effects they should be used carefully in patients with cardiac disease.

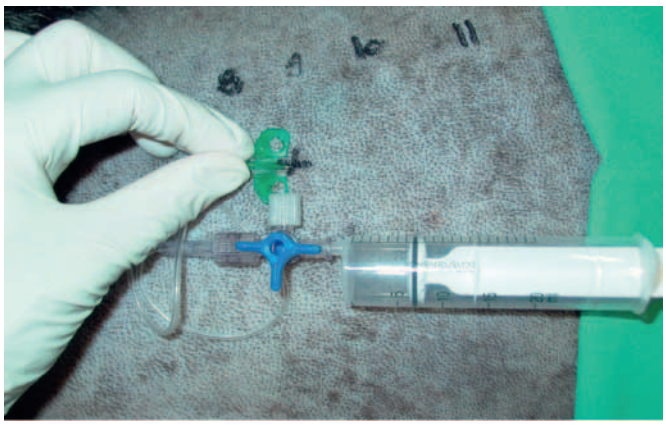
There is no specific treatment for lung contusions. These animals need oxygen supplementation, rest and analgesia [Jackson and Drobatz, 2004]. Antibiotics and steroids are generally not indicated [Powell *et al.*, 1999].

Pleural space

The parietal and visceral pleura form the pleural space, which for clinical localisation of respiratory distress- includes the mediastinum and the diaphragm. Animals with a pleural space disease often show asynchronous breathing with outward movement of the chest and inward movement of the abdomen during inspiration. This type of respiration is generated by changes in intrapleural pressure. Other authors describe a fast and shallow breathing or panting [Harpster, 2004; Silverstein and Drobatz, 2005].

The auscultation results may help differentiate between a pneumothorax, pleural effusion, or diaphragmatic hernia, respectively. With pneumothorax, the lung sounds are diminished dorsally, rather than ventrally as seen with pleural effusion. However, trauma patients with pulmonary contusions and pneumothorax may show apparently normal lung sounds (increased plus muffled = normal). A diaphragmatic hernia often causes a one-sided or at least asymmetrical attenuation of the lung sounds [Silverstein and Drobatz, 2005], and bowel sounds may be heard under certain circumstances [Bjorling and Sicard, 2004]. A pneumomediastinum may be associated with a subcutaneous emphysema of the neck or thoracic inlet [Macklin and Macklin, 1944].

Figure 3: Thoracocentesis using a butterfly catheter



The emergency treatment of animals with pleural space disease includes oxygen supplementation and the improvement of ventilation by thoracocentesis (for pneumothorax, pleural effusion), the elevation of the front half of the body (diaphragmatic hernia) or intubation and ventilation (diaphragm paralysis). Thoracocentesis should be carried out in all patients with decreased breath sounds on auscultation and an appropriate history of trauma. Thoracocentesis should preceed further diagnostic exams such as thoracic radiographs. Thoracocentesis is both diagnostically and therapeutically useful. Using a proper procedure, the risk of complications is very low. Thoracocentesis is performed in the upper third of the 7th to 9th intercostal space if a pneumothorax is suspected, and in the 5th to 7th intercostal space or under ultrasound guidance with pleural effusion [Sigrist, 2008a]. The aspiration site is clipped and prepared aseptically. If necessary, a local anaesthesia is performed with lidocaine. A butterfly catheter, IV catheter or a normal hypodermic needle can be used for the procedure. An extension set between the needle and 3-way stopcock with attached syringe is used for aspiration of air or fluid (Fig. 3). Generally, bilateral thoracocentesis should be performed. Recurrent pneumothorax is treated with a chest tube after the 3rd or 4th thoracocentesis in order to continuously evacuate the chest [Sigrist, 2008b].

Chest wall

Chest wall injuries (ribs, intercostal muscles) are very painful and therefore generally lead to very shallow breathing. The animals are often panting. Other clinical signs of chest wall injury are pain on palpation, subcutaneous oedema of the chest wall, and abnormal chest wall movements as seen with a flail chest. A flail chest results from segmental rib fractures and leads to a paradoxical movement of the affected region of the thorax during respiration [Capello *et al.*, 1995]. A flail chest is usually associated with severe chest trauma [Ciraulo *et al.*, 1994; Smith, 2004].

The treatment of chest wall injuries consists of adequate analgesia (see emergency stabilisation), treatment of associated lung injury, and primary wound care if necessary [Risselada *et al.*, 2008]. A penetrating chest wound should never be closed by a pressure bandage because the closure of the chest may lead to a life-threatening tension pneumothorax. Larger wounds can be protected by gauze, which is attached on 3 sides. For transport, a chest drain can be placed directly into the wound, but this needs to be under continuous suction or attached to a Heimlich valve. A Heimlich valve works only as long as it is not exposed to fluid, as any fluid will make it dysfunctional (as with a hemothorax).

Other causes of respiratory distress

Causes of respiratory distress may also be non-respiratory. Pain is a paramount differential diagnosis of tachypnoea, and a rapidly effective and potent analgesic (eg methadone 0.1-0.2 mg / kg IV) should be administered to all potentially painful patients prior to further investigations. Hyperthermia, shock, acidosis, and massive central nervous system disorders can also lead to tachypnoea or an abnormal type of respiration. The auscultation findings in these cases are often normal.

Diagnostic procedures

Diagnostic procedures associated with stress are in most cases unnecessary and should be performed in stable patients only.
If an intravenous access can be placed, blood can be obtained for a stat lab. Hematocrit, total solids, venous blood gases, glucose and examination of a blood smear may give helpful indications of possible causes of respiratory distress [Drobatz, 2000]. Thoracic radiographs provide valuable diagnostic information [Nitzl, 2009]. However, radiographs taken in patients with respiratory distress may lead to aggravation of respiratory signs. Meaningful radiographs require proper positioning [Nitzl, 2009], which may lead to destabilization of the animal and potentially lead to respiratory arrest. Therefore, only stable patients should undergo diagnostic imaging. Chest X-rays may be helpful to give a prognosis, document any progress of the disease, or obtain a diagnosis if initial stabilization measures were not successful.
The only accurate way to measure the blood oxygenation is by means of an arterial blood gas analysis [Drobatz, 2000]. The measurement of SpO2 allows an indirect assessment. Normal saturation values are > 95%. If the measured value is <90%, a significant oxygenation problem must be expected and the patient should be supplemented with oxygen, or be intubated and ventilated, respectively [Fairman, 1993].
Fluid obtained by thoracocentesis should be analysed including measurement of total solids, haematocrit, cell count and include a cytologic evaluation in order to distinguish between a transudate, a modified transudate and an exudate (septic, inflammatory, neoplastic). This classification will further reduce the list of potential differential diagnoses [Sanders and Sleeper, 2004]. Analysis of oedema fluid may also give an indication regarding the oedema type. Fluid resulting from non-cardiogenic pulmonary oedema is more protein-rich than fluid from cardiogenic pulmonary edema [Rozanski *et al*., 1998].

Monitoring

The respiratory rate and the type of respiration should be regularly monitored, since they may change depending on the cause of respiratory distress and may also worsen after initial improvement. The body temperature should also be regularly monitored in patients with dyspnoea, as the increased muscle work can lead to hyperthermia [Holt and Brockmann, 2004].
Heart rate, pulse quality, mucous membrane colour and SpO2 measurements allow the monitoring of oxygenation and should therefore also be checked regularly [Fairman, 1993]. In the intubated patient, measurement of end-tidal CO2 provides important information regarding ventilation. In the awake patient, this information can be obtained by the analysis of arterial or venous blood gases. Cyanosis is a very late clinical sign of hypoxia and requires immediate treatment. Cyanosis occurs when more than 5 g / dl haemoglobin is unsaturated [Lee and Drobatz, 2004]. Therefore, anaemic patients will never show cyanosis, despite massive hypoxia!
After stabilisation of respiration and normalisation of blood oxygenation, the transport of oxygen to the tissues must be ensured by an appropriate circulation.

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REPRINT PAPER (A)

Feline ear polyps: Two case reports and a model for pathogenesis – chronic otitis media with effusion

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SUMMARY

Inflammatory ear polyps are the most common non-neoplastic masses in the middle ear of the cat. These polyps tend to occur in younger cats. The two cases described in this paper show that ventral bulla osteotomy is a promising surgical option to successfully manage the condition and prevent recurrence. Cytologically, these polyps show all the characteristics of a chronically inflamed middle ear mucosa, i.e. massive lymphocytic and purulent inflammation as well as metaplasia of the mucoperiosteum displaying ciliated columnar epithelium and goblet cells. Impression smears of the polyps also show lymphocytes in follicular arrangement. Cytology is a suitable method to quickly obtain a preliminary intraoperative diagnosis.

However, this initial diagnosis needs to be confirmed by histological examination of biopsy samples. Chronic otitis media with effusion (COME) is a possible cause of the disease. It can also serve as a model to explain the pathogenesis of inflammatory auro-nasopharyngeal polyps in the cat.

Abbreviations: COME = chronic otitis media with effusion; MALT = mucosal-associated lymphoid tissue; VBO = ventral bulla osteotomy

Keywords: Otitis media, ear polyp, cytology, metaplasia, cat

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Introduction

Ear polyps are nodular and often pedunculated non-neoplastic masses, which originate from the mucosal lining of the middle ear and/or from the transition zone to the Eustachian tube [Pope and Constantinescu, 2000].

They tend to occur in younger cats [Donnelly and Tillson, 2004], but have also been reported in older cats aged up to 15 years [Faulkner and Budsberg, 1990; Veir et al., 2002]. Cats often suffer from otitis media due to viral infections of the upper respiratory tract [Venker-van- Haagen, 2005]. Polyps are considered a late sequela of the chronification of an inflammation of the middle ear [Salvinelli et al., 1999; Fan and De Lormier, 2004; Zender et al., 2007].

The middle ear is formed by the tympanic cavity and the embedded auditory ossicles. The major portion, the tympanic cavity, is a hemispherical bulla with a smooth surface, projecting above the base of the feline cranium. A medially protruding septum divides the cavity incompletely into a ventral and a dorsal compartment. The auditory tube, a narrow bony and cartilaginous channel, connects the middle ear to the nasopharynx [Seiferle, 1984].

The lining of the bony middle ear wall consists of modified respiratory squamous epithelium. The thin and poorly vascularised mucosa closely overlies the periosteum and has therefore been named mucoperiosteum [Paul, 2008]. The mucoperiosteum contains some ciliary and secretory cells as well as goblet cells [Seiferle, 1984; Jung HWA Pieper, 2003]. In the region of the promontory, on the medial wall of the middle

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ear, and particularly in the transition zone to the Eustachian tube, cuboidal to columnar stratified epithelium, with or without kinocilia, and goblet cells can be found. The transition from modified squamous epithelium to respiratory epithelium with kinocilia is continuous [Arnold, 1977; Harvey et al., 2003; Liebich, 2003). The Eustachian tube is completely lined with stratified ciliated epithelium containing goblet cells [Liebich, 2003]. Inflamed mucoperiosteum contains highly organized lymphatic tissue called MALT (mucosal-associated lymphoid tissue). In humans and in rats, it has been demonstrated that no lymphatic follicles develop in the normal, non-inflamed mucosal membrane of the middle ear. Lymphoid follicles require an external stimulus to develop, e.g. a viral or bacterial pathogen. Paul (2008) called this the "triggered dynamics" of the development of MALT.

Depending on the cause, and under the influence of pathophysiological conditions in the middle ear (partial pressure of carbon dioxide and oxygen), inflamed mucoperiosteum undergoes muciparous or keratinizing metaplasia [Parker and Binnington, 1985; Kuijpers et al., 1996; Esterline et al., 2005; De Lorenzi, 2005; Ressel and Poli, 2007; Paul, 2008; Rossi, 2009]. In addition, lymphatic follicles can always be found in the submucosa. Aural discharge, pruritus and pain are the most common clinical signs of otitis media. Some animals also show neurological symptoms such as head tilt, nystagmus, Horner´s syndrome or facial nerve paralysis. Up to one third of the patients develop deafness in the affected ear [Anders et al., 2008; Diel, 2008]. If inflammatory polyps reach as far as into the nasopharynx, animals display respiratory symptoms [Macphail, 2008; Werner-Tutschku, 2008].

In the literature, two methods have been discussed for removing ear polyps.

1) One option is the manual removal by traction-avulsion via the ear canal, a method, which is related to high recurrence rates [Anderson et al., 2000]. Recently, this technique has been further developed performing "perendoscopic transtympanic excision" [Mortellaro et al., 2001; Diel, 2008].

2) Ventral bulla osteotomy (VBO) is a surgical procedure to remove ear polyps and may produce complications e.g. Horner´s syndrome, vestibular disturbances, otitis media, haemorrhage, hypoglossal nerve damage, facial nerve paralysis and damage to the structures of the auditory apparatus. However, recurrence rates are lower after ventral bulla osteotomy [Donelly and Tillson, 2004].

In humans, COME often occurs without perforation of the tympanic membrane or without otorrhoea and may therefore take an asymptomatic course. In cases with late clinical manifestation, sensorineurally induced reduction of the patient´s ability to hear, acute exacerbation of a chronic otitis media and complications regarding the bony structures may occur. Starting as a simple purulent, and at a later stage mucopurulent, inflammation, the condition may worsen producing granulation tissue (polyps) and cholesteatomas.

In most cases, the disease is caused by a viral infection of the upper respiratory tract and the resulting acute middle ear infection. Babies and infants are predominantly affected, particularly those who are cared for in nurseries.

The larger the number of children living together, the higher the incidence of upper respiratory tract diseases. Bacterial contamination as a sequela of an impaired auditory tube function and massive development of subepithelial follicles, serving as a histomorphological substrate, are perpetuating factors of chronic otitis media with effusion (COME) [Sautter and Hirose, 2007; Paul, 2008].

Inflammatory mediators also play an important role in the development of COME. Bacterial endotoxins perpetuate the condition by migrating into the inner ear where they cause a loss of auditory capacity [Juhn et al., 2008].

Material and methods

Cytology

A sample of the aural discharge is retrieved from the ear canal using a cotton swab. The collected sample is then rolled onto a glass microscope slide and stained using Haema Schnellfärbung® (quick stain) (Labor+Technik, Berlin, Germany) and evaluated under the light microscope. Intraoperatively, cells are obtained by direct impression smear and then stained using Haema Schnellfärbung® as well as modified May-Grünwald Eosin Methylene Blue® (Merck, Darmstadt, Germany) and Giemsa® (Merck, Darmstadt, Germany) before evaluating them under the microscope.

Imaging techniques

Lateral oblique and rostrocaudal radiographs are taken of the sedated patient, as described by Harvey et al. (2003).

Surgery

Venker-van Haagen (2006) describes the traction-avulsion technique often used; Knudig (2002), Harvey et al. (2003), White (2003) and Grevel (2005) describe how to perform a ventral bulla osteotomy.

Anaesthesia and analgesia

To sedate patients for radiographic examination and to anaesthetize them prior to surgery, medetomidine at a dose of 0.05 mg/kg (Domitor®, Pfizer, Vienna) und ketamine (8 mg/kg (Ketamidor®, Richter Pharma, Wels) were given IM. Anaesthesia was maintained with isoflurane (Isoflo®, Abbott, Richter Pharma, Wels). Whenever necessary, a bolus of fentanyl (0.5 mg Fentanyl-Janssen®, Janssen-Cilag, Vienna) diluted in 100 ml 0.9 % saline solution (Natrium chloratum pysiologicum®; Fresenius Kabi, Graz) was administered via the infusion line, up to a maximum of 0.25 ml per kg body mass per 5 minutes. Before and after surgery, patients were given carprofen (2 mg/kg) (Rimadyl®, Pfizer, Vienna) as an analgesic.

Case details

Case 1

A 15-month-old castrated, regularly vaccinated, male Maine Coon cat with a body weight of 9.5 kg was presented with pruritus and pain in the right ear. The cat lived in a household together with one of his male litter mates. The second cat was asymptomatic. Clinical examination revealed unilateral purulent otitis. Differentials to consider include bacterial inflammation, *Malassezia* otitis, ear mange caused by *Notoedres*, allergic otitis and/or neoplasias in the external ear canal or the middle

ear. First samples were taken for smear preparations and the external ear canal was examined using an otoscope. Cytological findings revealed the presence of neutrophil granulocytes with large quantities of phagocytised cocci, consistent with bacterial otitis.

Due to the copious purulent otic discharge, the tympanic membrane could not be evaluated. The cat received marbofloxacin 2 mg/kg s.i.d. PO (Marbocyl®, Vetoquinol, Vienna) for one week together with a topic treatment b.i.d. (0.05 % chlorhexidine otic solution; Clorexyderm®, ICF, Cremona, Italy).

At follow-up examination, the volume of the otic discharge was significantly reduced. Haematological and blood chemistry findings were normal. The patient was sedated according to the previously described protocol and the ear canal was cleaned using diethylhexyl sodium sulfosuccinate and urea hydrogen peroxide (Otoprof®, ICF, Cremona, Italy).

The following otoscopic examination revealed a pink bulging mass in the region of the tympanic membrane; remnants of the ruptured eardrum could be discerned at the wall of the external ear canal. The patient was diagnosed with otitis media with eardrum perforation caused by an ear polyp.

The soft palate was carefully elevated using a feline spay hook to visualize the pharynx, but no nasopharyngeal polyps were detected. Radiographic examination in oblique lateral projection showed a soft tissue opacity in the right tympanic cavity. The contralateral bulla appeared as a thin-walled dense bony structure (Fig. 1).

The owner agreed to have the polyp removed using the traction-avulsion technique (Fig. 2). Samples for bacteriological culture and histopathological examination were obtained during surgery. Postoperatively, antibiotic therapy was started with amoxicillin-clavulanic acid (Clavaseptin®, Vetoquinol, Vienna) at a dose of 20 mg/kg b.i.d. PO. Bacterial culture proved the presence of enterococcus sp., and the antibiogram showed that the responsible organism was sensitive to the initial antibiotic treatment, so the therapy was extended to a total of one month. Histopathology revealed that only some regions on the external surface of the polyp were covered by one or two layers of cuboidal epithelium, while the majority of the surface was eroded (Fig. 3a). In addition, some adenoid indentations with columnar ciliated epithelium were seen (Fig. 4a). In the loose connective and granulation tissue of the polyp stroma

Fig. 1: Oblique skull radiograph of the Maine Coon cat (Case 1). The healthy bulla (a) appears as a thin-walled dense bony structure at the base of the skull, while the affected right side (b) shows a soft tissue opacity in the tympanic cavity.

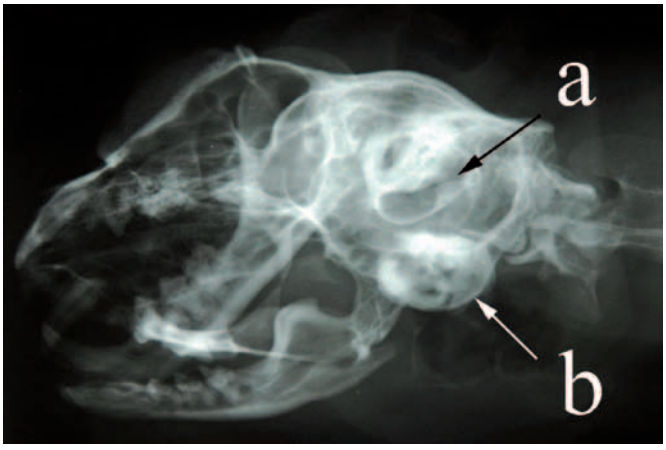
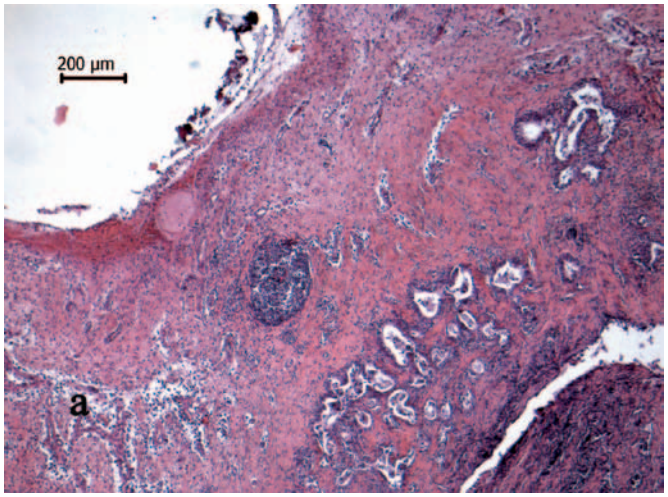
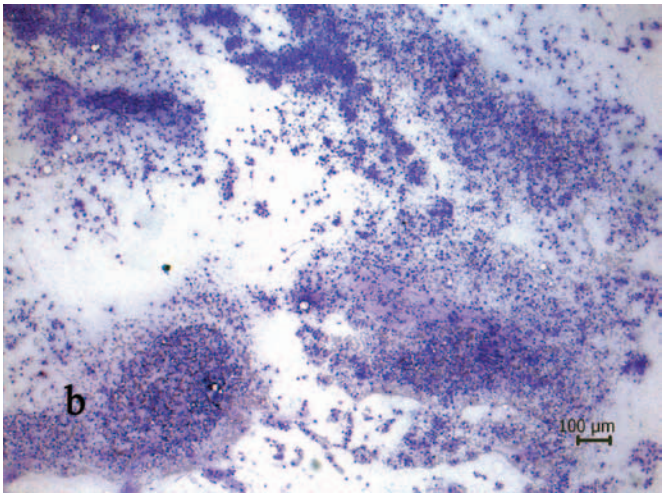


Fig. 2: Ear polyp removed by traction (size compared to a 1 € coin).

Fig. 3: Longitudinal histological section of the polyp of Case 1: a) In the loose connective and granulation tissue of the polyp stroma, follicle-like accumulations of small lymphocytes can be seen. b) Lymphocyte follicular aggregates are also observed in the impression smear preparation (Haemacolor).





follicle-like accumulations of small lymphocytes were found (Fig. 3b). The purulent inflammatory component was only mildly developed.

After only three weeks, the tympanic membrane was fully restored and closed, and the cat was discharged as healthy.

One year later, the cat was again presented, this time with bilateral nasal discharge and a unilateral purulent discharge from the right ear. After one week of pretreatment with amoxicillin-clavulanic acid and acetylcysteine 50 mg (ACC® Hexal, Hexal Pharma, Vienna) per meal twice daily, skull radiographs were taken revealing a soft tissue opacity. The opacity was interpreted as a regrowth of the ear polyp. The pharyngeal cavity was clinically normal.

This time, a ventral bulla osteotomy was the treatment of choice because this technique is associated with low recurrence rates. Due to the bone density of the ventral wall of the tympanic cavity in this Maine Coon cat, it was quite difficult to perform the osteotomy and achieve perforation of the bulla.

Again, samples for bacteriological and cytological examination were collected intraoperatively, and the removed polyp was submitted for histopathological examination. Bacteriological findings did not differ from those of the first examination.

At a magnification of x4, cytology was characterized by dark-blue cell accumulations consisting of numerous lymphocytes, plasma cells, many neutrophils, macrophages and phagocytised cocci (Fig. 3b). Outside these areas, columnar epithelium with (Fig. 4d) and without kinocilia (Fig. 4b) as well as some goblet cells were observed (Fig. 4c). Fig. 5 shows the stratified composition of the epithelia. Type and structure were compatible with metaplastic inflammatory ear polyps.

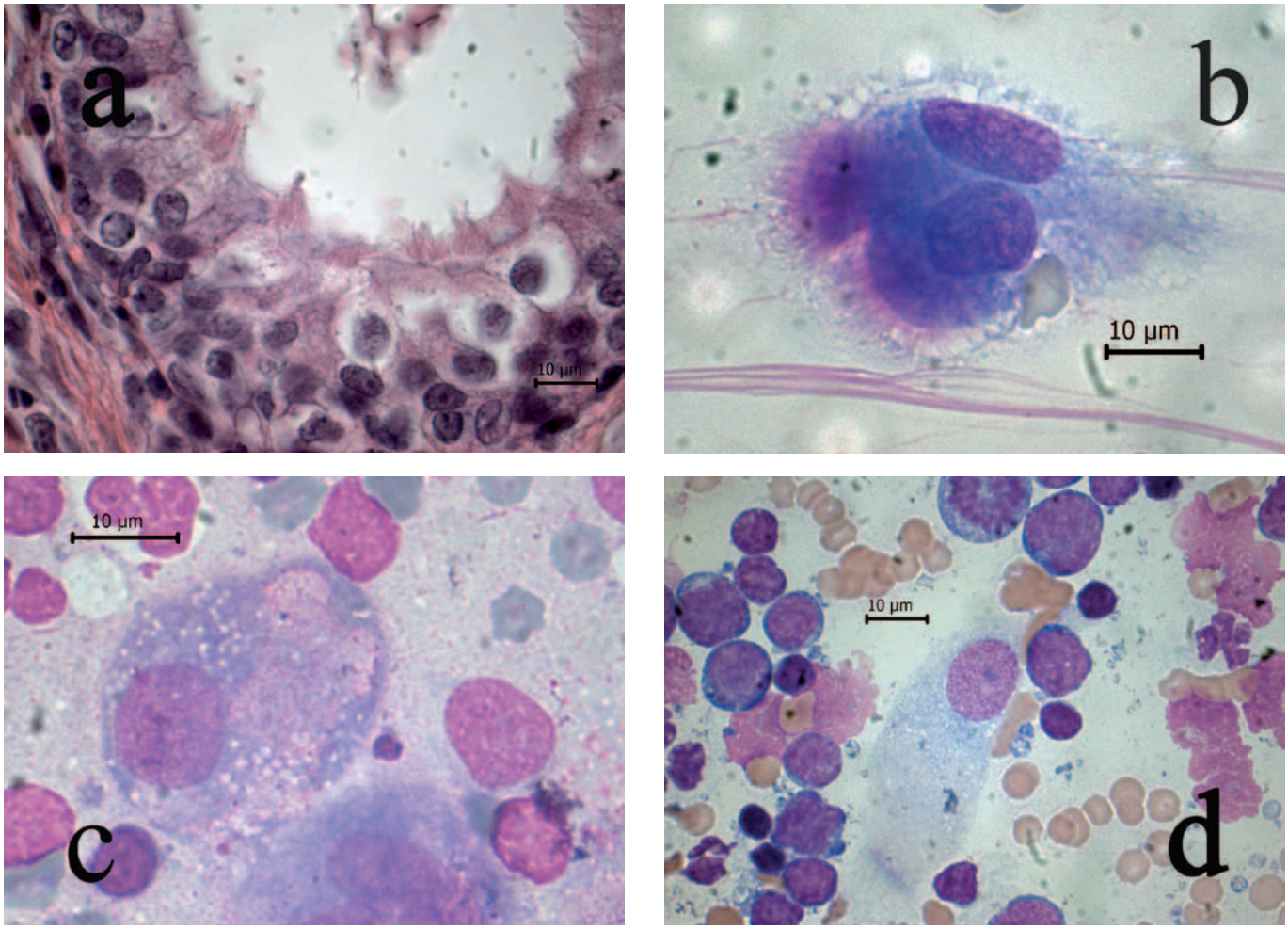
After one month of antibiotic therapy with amoxicillin- clavulanic acid (Clavaseptin®, Vetoquinol, Vienna) and once the eardrum had closed again, the cat was discharged as healthy.

Two years later, no regrowth of the polyp had occurred.

Case 2

A 10-month-old castrated European Shorthair cat with a body weight of 3 kg was presented with pruritus, pain and a yellow discharge in the right ear. The cat came from an animal shelter where she had contracted infectious rhinitis at the age of 8 weeks. She suffered from a severe nasal discharge and respiratory symptoms. At the age of four months, the cat was diagnosed with generalized dermatophytosis, which was treated successfully. The animal had received the usual vaccinations

Fig. 4 Details of Fig. 3: Pseudo-stratified columnar ciliated epithelium with goblet cells in a glandular invagination (a); (histological section). Cells with kinocilia (b) and numerous goblet cells (c) as well as columnar cells (d) can also been seen. In Fig. 4d, the epithelial cell is embedded in inflammatory tissue with large and small lymphocytes and plasma cells. Near the top margin, a lymphatic cell in division can be discerned (Haemacolor stain). Both cytological and histological findings are consistent with muciparous metaplasia of the respiratory epithelium.



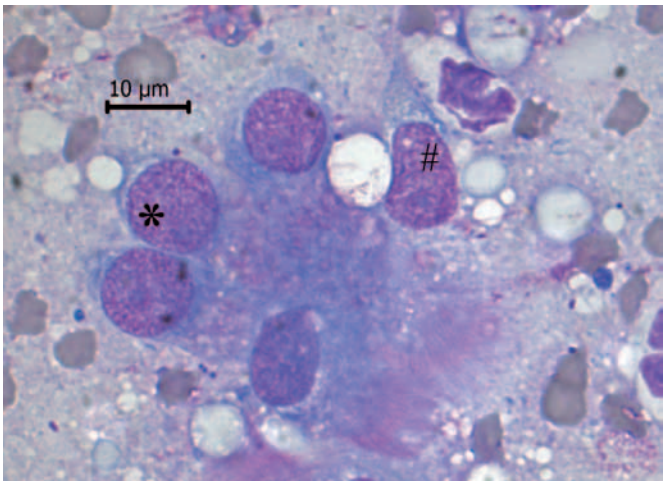
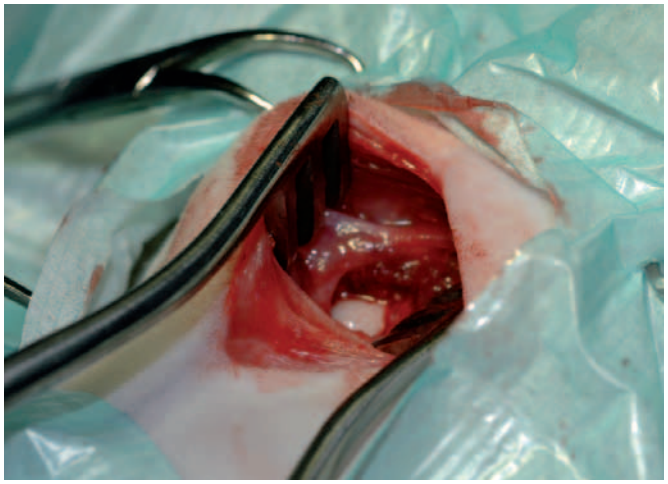


Fig. 5 Over a protein-rich background, there is a group of five cells displaying epithelial characteristics. Two types of cells can be seen: On one side, there are goblet cells (*) close to epithelial cells with eccentric nuclei and eosinophilic cytoplasm; on the other side, the ciliated epithelium (#) can be identified because of the elongated cell shape, the eccentric nucleus and the kinocilia. These five cell types are characteristic of a pseudo-stratified epithelium. Knowing the topographic location of the sample, this microscopic picture is consistent with muciparous, metaplastic, inflammatory mucosa of the middle ear.

regularly. Apart from the purulent otitis, the cat was clinically normal. After one week of antibiotic therapy (amoxicillin-clavulanic acid; Clavaseptin®, Vetoquinol, Vienna), the external ear canal could be examined with the otoscope, revealing a pink mass deep down in the ear canal. After sedation of the patient, rostrocaudal radiographs were obtained showing a soft tissue opacity in the right bulla (Fig. 6); the contralateral tympanic cavity did not show any pathological alterations. After cleaning the ear with Otoprof® (ICF, Cremona, Italy), the polyp could be visualized with the otoscope. The pharyngeal cavity

Fig. 7 Surgical field showing the affected bulla. The digastric muscle has been separated from the mylohyoid muscle, and a retractor is used to hold the wound open. The venous bifurcation lies ventrally just under the surface, while the hypoglossal nerve runs under the two dissected muscles.



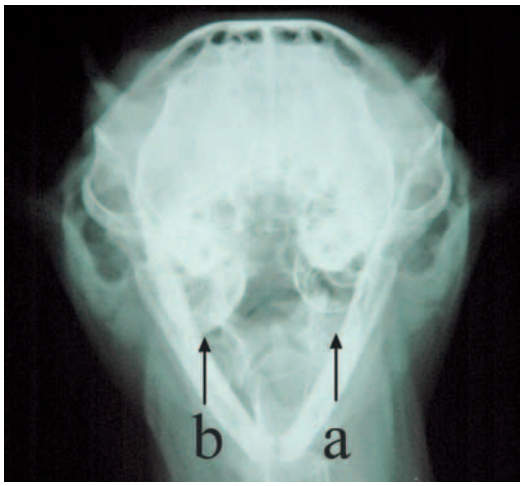


Fig. 6 Skull radiograph of the European Shorthair cat (Case 2). The healthy bulla (a) appears as a thin-walled symmetrical dense bony structure at the basis of the skull, while the affected side (b) shows a soft tissue opacity.

was examined as described in Case 1.

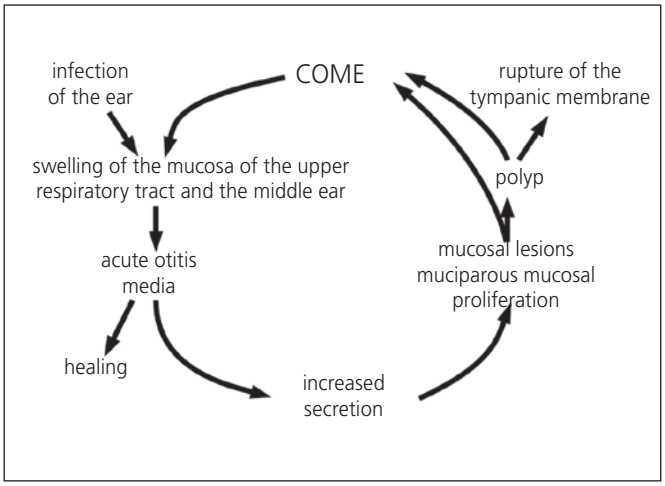
Due to the experience gained with the patient of Case 1, the immediate performance of ventral bulla osteotomy was suggested to the owners. In contrast to Case 1, osteotomy of the tympanic cavity and dissection of all relevant structures were performed very easily (Fig. 7). As usual, samples for bacteriological culture and cytological and histological examination were obtained during surgery. Findings showed the presence of diplococci sensitive to amoxicillin-clavulanic acid as well as haemolysing staphylococci.

Over a background of inflammatory cells containing neutrophils, lymphocytes, plasma cells and macrophages, the cell-rich impression smear preparation contained ciliated epithelial cells with a relatively high cytoplasm:nucleus ratio.

These epithelial cells were characterized by nuclei with clumpy chromatin, indicating an increased nuclear activity. Histology revealed an inflammatory infiltrate covered by a layer of prismatic, ciliated epithelial cells. Both findings are consistent with inflammatory ear polyps (Figs. 3, 4 and 5).

Postoperatively, reduced unilateral retractability of the tongue

Fig. 8 Self-perpetuating circle of chronic secretory otitis media.



was noticed, which resolved within the next four weeks. The tympanic membrane took more than two months to heal completely. During the four weeks after surgery, the cat received antibiotic treatment (amoxicillin-clavulanic acid, Clavaseptin®, Vetoquinol, Vienna). 24 months after performance of the ventral bulla osteotomy, the cat was still asymptomatic.

Discussion

Histopathological and cytological findings are consistant with the changes described by Paul (2008) in human patients with middle ear disease. As the healthy mucosa of the middle ear in both men and rats is practically devoid of lymphoid follicles, an increased presence of lymphoid follicles in the feline middle ear may also be considered characteristic of chronic inflammation. In young cats, just as in children, multiple viral and bacterial infections of the upper respiratory tract may cause inflammation of this kind. In most young animals, infections of the upper respiratory tract are asymptomatic or show a mild course. As in humans, middle ear infections in the cat often occur unnoticed, as they are almost always self-limiting. The majority of cases of ear polyps published in studies refer to young animals. In only a very small number of affected animals, the condition is preceded by clinically manifest symptoms of an upper respiratory tract disease [Veir et al., 2002; Mac Phail et al., 2007]. The Maine Coon cat, in Case 1, showed nasal discharge at the time of regrowth of the polyp, which in this case was most probably a sequela and not the cause of middle ear inflammation. In Case 2, the European Domestic Shorthair cat had suffered from massive upper respiratory tract disease at the age of eight weeks, with the ear polyp only developing seven to eight months later. In an analogy to man, living in a densely populated surroundings also represents a contributing factor in the cat (in this case, the patient lived in an animal shelter). Densely populated catteries carry a high risk of transmitting upper respiratory tract infections. The type of metaplasia depends to a great extent on its anatomical location. Nasopharyngeal polyps growing from the Eustachian tube into the pharynx may develop a keratinizing epithelium due to increased contact with oxygen [Esterline et al., 2005].

However, one of the authors (a pathologist) affirms that he has never diagnosed keratinization in nasopharyngeal polyps. Both cases described in this paper can be clearly related to the respiratory epithelium as the tissue of origin; this was confirmed by both histological and cytological findings. In particular, the metaplasia can be diagnosed cytologically on the basis of the tissue structure (Fig. 5).

Both cats presented here exclusively displayed symptoms compatible with otitis externa or otitis media, respectively, which in both patients affected one side only. In the literature, this complex of symptoms is often referred to as otorrhea, visible polyps, sneezing and/or nasal discharge [Anderson et al., 2000; Harvey et al., 2003]. In contrast, no central nervous symptoms were observed in either of the cases. One explanation could be that the cats were presented in a very early stage of the condition and that the immediate onset of appropriate therapy prevented the development of central nervous symptoms. As far as a possible breed predisposition is concerned, no binding statement can be made, as the total case volume - approximately 130 published cases since 1990 – is quite small. What is striking, however, is the fact that Maine Coon cats are listed in all reported cases [Kapatkin et al., 1990; Anderson et al., 2000; Veir et al., 2002; Diel, 2008]. This may suggest a predisposing anatomical conformation of the auditory tube in this breed. Before CT and MRI had started to be widely used as imaging techniques, radiography was the only means to visualise the tympanic cavity and several authors have described this technique [Harvey et al., 2003]. However, Remedios et al. (1991) point to its low sensitivity as 25% of the findings are false negative. If the clinical presumptive diagnosis cannot be confirmed by radiology, computed tomography is the method of choice to achieve a final diagnosis.

Although the traction-avulsion method is an accepted technique for removing nasopharyngeal polyps [Werner-Tutschku, 2008), the correct initial treatment for polyps in the middle ear is still discussed controversially in the literature: While some surgeons advocate traction-avulsion of the polyp [Gotthelf, 2000; Diel, 2008], others consider ventral bulla osteotomy as the method of choice [Trevor and Martin, 1993; Anderson et al., 2000; Muilenburg and Fry, 2002; Harvey et al., 2003; Anders et al., 2008; Macphail, 2008]. Both Gotthelf (2000) and Diel (2008) removed polyps under endoscopic control by traction and avulsion applied to the stalk of the polyp. Trevor and Martin (1993), in contrast, removed ear polyps in 22 cases performing ventral bulla osteotomy; seven of these procedures were performed to remove inflammatory ear polyps and no regrowth was observed in these patients. Anderson et al. (2000) published a retrospective study with 37 cases; of these, 30 cats underwent removal of the polyp by traction-avulsion. Follow-up examinations were carried out in 22 animals, of which nine (41%) developed recurrences. That case study did not mention details of the applied technique of polyp resection. The success rate of the traction technique is clearly higher when applied to polyps in the Eustachian tube rather than to polyps in the external ear canal. However, considering the total number of surgeries for polyp removal, ventral bulla osteotomy proved to be superior to the traction method. Anders et al. (2008) found that ventral bulla osteotomy as a surgical technique can neither cure deafness caused by the polypoid condition nor damage an intact sense of hearing in an animal.

As can be deduced from literature, ventral bulla osteotomy has a high success rate as it is a reliable method to permanently remove inflammatory ear polyps without the risk of recurrences; the two cases described in this paper fully confirm this. If the traction method is performed under endoscopic control, a lower recurrence rate seems to be possible. Traction-avulsion without any visual assistance is less successful - as could be seen in Case 1. Another explanation for the reduced success rate of the traction-avulsion technique could be the fact that considerable quantities of inflammatory tissue and – even more importantly – of pus and mucus remain in the middle ear despite proper lavage. Most probably, this does not alter the microclimate in the middle ear (sero-purulent material and reduced oxygen partial pressure) sufficiently, preventing involution of the metaplasia. The situation is different with ventral bulla osteotomy.

The better approach via the ventral aspect of the tympanic bulla enables performance of a meticulous curettage of the inflamed mucosa. In addition, remaining liquid and other material can easily drain and air can enter to ventilate the middle ear. The

higher oxygen partial pressure and reduced quantity of mucus facilitate reversion of the metaplasia.
Faulkner and Budsberg (1990) reported that a wide range of bacterial agents was isolated from the samples obtained from the tympanic cavity of the 12 patients studied. In the two cases described in this paper many different organisms were isolated; however, two cases are insufficient to permit a scientifically relevant conclusion.
Cytology yielded similar results in both patients: inflammatory cells and non-keratinising prismatic epithelium [Corazza and Poli, 2007] or ciliated epithelium as well as goblet cells (Fig. 3 and 4). Cytology is a suitable method to allow intraoperative differentiation between inflammatory/metaplastic and neoplastic masses. In selected cases, the differentiation between dysplastic and neoplastic cells can be difficult due to the massive inflammatory process. Quick stains tend to overemphasize the malignancy criteria, while the May-Grünwald-Giemsa staining method has delivered an optimal performance in such cases. The suitability of cytology as a diagnostic tool to evaluate tumours in the middle ear has been proven by De Lorenzi et al. (2005).
In human medicine, chronic secretory media with effusion was unknown prior to the advent of antibiotics [Sautter and Hirose, 2007]. In veterinary literature, it is also remarkable that the number of published cases of the condition has dramatically increased since the 1970s. The fact that it is more frequently diagnosed than before may be related to the increased use of antibiotics for the treatment of infectious diseases of the upper respiratory tract and the increasing application of topical otic preparations. Considering the state of knowledge in human medical literature and the course of the two cases described in this paper together with the histological and cytological findings, the concept of a chronic otitis media with effusion as described by Sautter and Hirose (2007) may also be considered as a valid hypothesis in feline medicine.

Chronic otitis media with effusion (COME) – a possible pathophysiological course

(Fig. 8). At the beginning, there is an infection of the upper respiratory tract. This may occur without or with only mild clinical signs [Ibarolla et al., 2005). However, a generalized lymphatic reaction of the mucous membranes in the affected region takes place. Mucosal swelling in the upper respiratory tract and frequent sneezing lead to an increased pressure in the nasopharynx and to the opening of the auditory tube. With the reflux flow from the pharynx, infectious organisms are transported into the middle ear (Sautter and Hirose, 2007).
Due to the inflammation, oedema of the epithelium in the Eustachian tube develops, resulting in an occlusion of the tube.
The occluded tube produces negative pressure within the cavity system of the middle ear. With serous liquid penetrating the tympanic cavity, a process of transformation into columnar respiratory epithelium is induced. Dysfunction of the auditory tube is considered a decisive aetiological factor for middle ear inflammation [Paul, 2008]. Independently from an invasion of the tympanic cavity by infectious agents, the mucous membrane of the middle ear has already reacted. Oedema, hyperplasia and metaplasia of the mucosa as well as development of follicles in the submucosa, are the consequences [Arnold, 1977; Veir et al., 2002]. Neither mucosal-associated tissue (MALT) nor large numbers of goblet cells or intraepithelial glands form part of the healthy mucosa, but are the result of a reaction to stimuli.
There is a continuous drop in oxygen partial pressure, while the partial pressure of carbon dioxide is continuously rising. Secretions and inflammatory mediators also play an important role. The result is a reduced frequency of movement of kinocilia and, as a consequence, a reduction in mucociliary clearance [Paul, 2008; Juhn et al., 2008].
The process may resolve either without treatment or due to therapeutic measures against the causative organisms and the inflammation, putting an end to the occlusion of the auditory tube and inducing a partial involution of the mucosal metaplasia. If the disease process progresses, the inflammation becomes purulent and the oxygen partial pressure decreases more and more.
The continued inflammatory process with the development of lymph follicles, increased production of mucus by the goblet cells and increased secretion of the intraepithelial glands, together with the confines of the tympanic cavity and the auditory tube activates a vicious circle [Paul, 2008], in which inflammatory mediators play an important role [Juhn et al., 2008]. Due to this self-sustaining chronification of the process, massive proliferation of the metaplastic mucosa occurs leading to the development of granulation tissue and polyps [Salvinelli et al., 1999; Paul, 2008; Juhn et al., 2008). With increasing growth, the polyp impinges on the eardrum, which is already affected by the inflammation.
As a consequence, the tympanic membrane ruptures and bacterial contamination occurs. Toxins and/or applied drugs may damage the sense of hearing [Venker-van Haagen, 2006].
The performance of a ventral bulla osteotomy may stop the inflammatory process and even reverse it, although full recovery is not possible with this method once a sensorineural hearing loss has occurred [Anders et al., 2008].
Ventral bulla osteotomy enables surgeons to advise pet owners before surgery regarding the favourable prognosis and the possible risk of recurrence. The traction technique under optical control is a promising procedure, although a realistic evaluation of this method requires more cases as a basis for assessment. Intraoperative cytological examination showing ciliated metaplastic epithelium is a suitable tool to quickly evaluate and differentiate the tissue samples obtained during surgery. The bacterial component involved in the inflammatory process is extremely variable. In both cases described in this paper, the organisms were fully sensitive to amoxicillin-clavulanic acid. Chronic otitis media with effusion is a possible model for the pathogenesis of ear polyps in the cat.

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REPRINT PAPER (N)

Herpes virus infection in the dog – A review

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INTRODUCTION

Canine herpes virus (CHV1) infection has been reported in many European countries with the prevalence of antibodies against CHV1 varying from 40% to 88% in healthy dog populations in Belgium, the UK and the Netherlands. Although the disease occurs sporadically in Norway, its seroprevalence is unknown. In the adult dog, CHV1 infection causes only mild clinical signs, which are often not observed by the owner. However, in neonatal puppies, the virus can produce systemic fatal haemorrhagic disease. In-utero infection during pregnancy may cause infertility, abortion or birth of weak pups, depending on the stage of gestation when infection occurs. CHV1 infection has also been associated with tracheobronchitis and papulovesicular genital lesions. The authors discuss prophylactic measures to prevent neonatal disease and infection of the bitch during pregnancy. A vaccine is licensed for use in the European Union to protect puppies against CHV1 infection during the first two-three weeks of life by transfer of maternal antibodies. The bitch is vaccinated twice during pregnancy. The authors emphasise that vaccination is optional and should be used only where an increased risk of neonatal CHV1 infection exists.

Key words: canine herpes virus, dog, neonatal infection, reproduction, review

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Introduction

Recently, many veterinarians and breeders have been in contact with the Norwegian School of Veterinary Science and the National Veterinary Institute concerning herpes virus infection in dogs. A vaccine has recently been licensed for use in several European countries, creating the need for increased knowledge of this infection.

Canine herpes virus (CHV1) infection was first reported in the USA in the early 1960s [1]. In neonatal puppies, the virus can produce systemic fatal haemorrhagic disease [2]. In the bitch, herpes virus infection can cause reproductive failure [3], but its importance in upper airway infections in dogs is unclear [2,4]. In adult dogs the infection is usually asymptomatic. CHV1 infection has been reported from many European countries, and several serological studies indicate that CHV1 is widely spread in dog populations. In studies from Belgium, the UK and the Netherlands, the prevalence of antibodies against CHV1 varies from 40% to 88% in healthy dog populations [5,6,7]. Serum samples collected from 19 of 38 kennels in the Gauteng province of South Africa tested positive for CHV1 antibodies [8]. In a Finnish study of kennel dogs with and without reproductive problems, a significant difference was found in the percentage of seropositive dogs between the two groups [9]- all dogs from the kennels with reproductive problems were seropositive for the virus. In Sweden, more than 50% of the dog population is expected to have been exposed to the herpes virus [10] (Lena Renström, the National Veterinary Institute, Uppsala, personal communication). In Norway, herpes virus infection was first diagnosed in neonatal mortality in 1973 by Bratberg et al [11]

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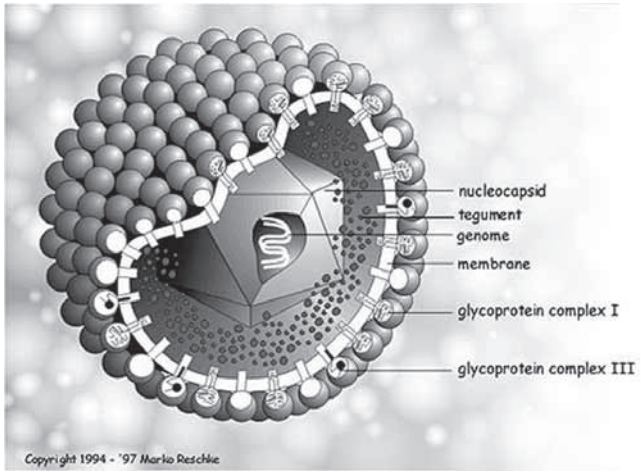
and over the past 20 years the infection has continued to be diagnosed sporadically [12,15]. The prevalence and importance of herpes virus infection in Norwegian dogs is still unclear. This article is a review of herpes virus infection in dogs.

Canine herpes virus 1

Canine herpes virus 1

CHV1 is a relatively large, enveloped doublestranded DNA virus belonging to the family *Herpesviridae* and the subfamily *Alphaherpesviride*, genus *Varicellovirus* (Figure 1) [16]. It has a relatively narrow host range, being pathogenic, in only domestic and wild animals of the *Canidae* family. This host specificity is caused by CHV1-specific receptors at the cell surface [17]. At present, only one antigen type of CHV1 has been detected. A relatively close genetic relationship exists between canine and feline herpes viruses [18,19]. The herpes virus is sensitive to environmental factors [2]. It is inactivated after 22 hours at 37°C and more quickly at higher temperatures. Freezing of samples to -20°C gives some reduction in live viruses, but is nevertheless recommended when shipping samples to laboratories [2]. The virus is quickly destroyed at pH levels of <5 or >8 and by of most disinfectants. CHV1 replication is optimal in the temperature range 35-37°C in vivo and in vitro, which resembles the temperatures in the mucosa of the upper airways and reproductive tract [2,16]. Replication of CHV1 occurs in the cell nucleus and gives rise to intranuclear inclusion bodies which are of diagnostic value. Typically, as for most alpha herpes viruses, lifelong latency follows infection. The virus enters a latency period during which only parts of the genome are expressed [16]. This virus genome is usually localised in nerve ganglia and lymphoid cells [20]. Using a polymerase chain reaction (PCR), Burr and coworkers detected DNA from CHV1 in lumbosacral ganglia and tonsils in 5 of 12 older dogs without a history of herpes virus infection [21]. Virus DNA was also found in the parotid salivary gland and the liver. The authors suggested an association between localisation of the virus and the route of shedding from the reproductive or oronasal mucosa. During latency, no virus replicates and the host cell is probably undamaged. Reactivation of the virus with multiplication and shedding from mucosal surfaces has been shown in several studies [22,23]. In bitches treated with prednisolone (600 mg per day for five days) who had a history of abortion induced by the herpes virus, CHV1 was detected from the oronasal and vaginal mucosa and from the tonsils and ocular fluids [22]. Another study showed that repeated reactivation within one to three month intervals can also be induced by immunosuppressive therapy [23]. It has been demonstrated that stress, proestrous and gestation can reactivate the virus, but the mechanism by which this happens is not clear [2].

Figure 1. Canine herpes virus. (Photo: Marko Reschke, Biografix, Germany, copied with permission).



Pathogenesis and clinical findings

Herpes virus infection in dogs manifests itself in different ways, depending on age, gender, immune status, and route of virus transmission.

Infection during pregnancy

If the virus reactivates or a primary infection of CHV1 occurs during pregnancy, there is a risk of transplacental transmission to the fetus [24, 25]. Viraemia in the bitch can also produce degenerative and necrotic lesions in the placenta [26]. The outcome of the pregnancy depends on the developmental stage of the foetus at the time of infection. Mummification of several foetuses has been reported in some bitches following intravenous virus administration at day 30 of gestation, whereas abortion or birth of mummified fetuses and the presence of dead or live pups was observed in the litters of other bitches [24]. Bitches inoculated at day 40 of pregnancy gave birth to dead and live pups one week before term. The live pups were weak and died shortly afterwards. With inoculation of the virus at days 48-53 of pregnancy, live puppies were born, but most of these were weak and died within two weeks with symptoms characteristic of herpes virus infection [25].

Naturally infected bitches experiencing reinfection during pregnancy often have milder disease than in primary infections [2]. Specific antibodies in the serum and colostrum of the bitch protect the fetus and offspring and consequently reduce the risk of abortion, stillbirth, or birth of weak puppies.

Neonatal infection

Puppies are most vulnerable to septicaemic infection during the first two weeks of life [1,27,28]. Virus transmission is usually via the oronasal route. The puppies may also be infected during birth if the virus is present in the reproductive tract. The pathogenesis of CHV1 infection is studied by challenging puppies of different ages. After oronasal inoculation, the virus replicates in epithelial cells and the tonsils [2] then spreads to the blood via monocytes. Viraemia occurs on day three or four after infection. The highest concentration of viruses is found in the kidneys, adrenal glands, lungs, liver, and spleen. Massive endothelial damage with necrotising vasculitis develops in blood vessels, leading to multiple necroses and haemorrhage in different organs. Systemic infection with CHV1 is often followed by generalised thrombocytopenia. CHV1 can be transported along nerve axons to the central nervous system and induce meningoencephalitis [29]. Neurological signs are usually not present because the outcome is fatal before these develop. The

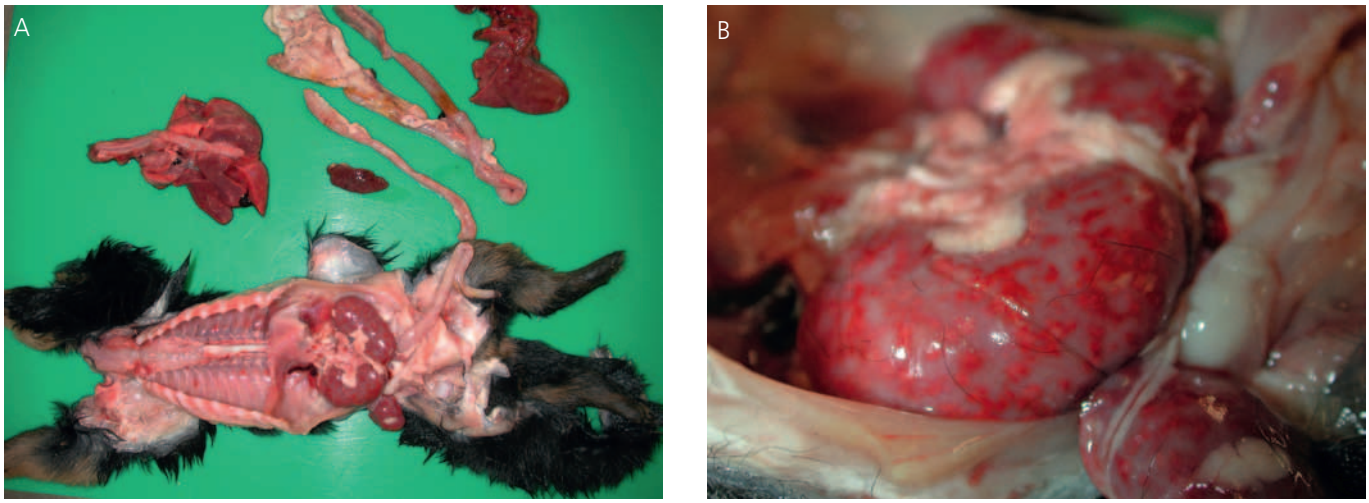


Figure 2. A) Autopsy of a two weeks old rottweiler puppy that died from septicaemic herpes virus infection. B) Characteristic haemorrhages are seen macroscopically in the kidney (Photos in Figures 2-4 by Dr. Øyvor Kolbjørnsen, National Veterinary Institute, Oslo).

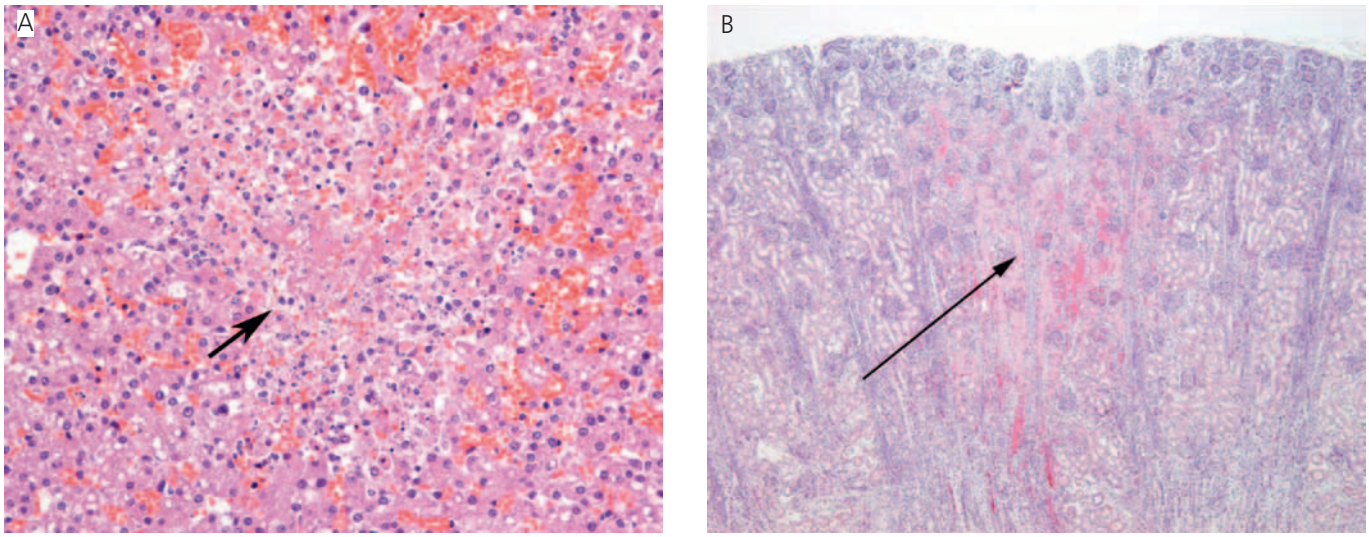


Figure 3. A) Histo-pathology of liver section and B) Kidney section. The arrow indicates an area of focal necrosis and hemorrhages. Hematoxylin-eosin staining. 200x.

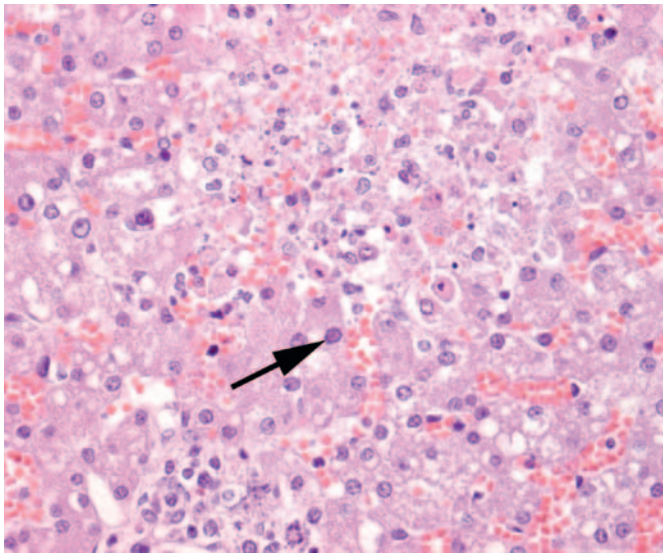


Figure 4. Histo-pathology of liver section. The arrow points at an intranuclear inclusion body in a hepatocyte. Hematoxylin-eosin staining. 400x.

retina develops during the pup's first weeks of life and CHV1 is associated with corneal lesions and retinal dysplasia [30,31]. Herpes virus infection is more serious for newborn pups than for six-week-old pups [32,33]. Puppies are particularly vulnerable during the two first weeks of life because of impaired body temperature regulation [34,35]. Rectal temperature is normally 1-1.5° below adult temperature and the ability to respond to infection with fever is reduced [35]. Between four and eight weeks of age, systemic infection develops after CHV1 inoculation if the body temperature is artificially lowered [2,34]. Elevation of the environmental temperature may reduce the severity of CHV1 infection in one week old pups, but not eliminate it.

The humoral immune status for CHV1 in the bitch is of extreme importance in the development of infection in the offspring [2]. Puppies nursed by a seronegative dam are at a high risk of developing a fatal systemic infection if they are infected, whereas maternal antibodies from a seropositive dam will protect the pups against generalised infection. Incubation time for CHV1 infection in newborn puppies is from one to a few days and disease progression is often rapid with a fatal outcome. In more

protracted cases, poor ability to suckle, inactivity, abdominal pain, and a characteristic sound are observed. Diarrhoea, serosanguinous nasal discharge, and mucosal and ventral abdominal haemorrhage are occasionally seen [2]. Although shivering and squeaking, the juvenile puppy does not respond by increasing it's body temperature. Ultimately, it becomes unconscious and may develop ophisthotonus and spasms before death occurs, mostly within 24-48 hours after the initial signs. Puppies who survive may develop such neurological signs as ataxia, blindness and balancing difficulties. Those infected from three weeks of age may develop eye lesions and neurological signs secondary to non-suppurative meningoencephalitis [29], or may develop a milder or asymptomatic disease.

Infection in the genital tract of adult dogs

CHV1 infection has been associated with papulovesicular lesions on the penis and prepuce in the male dog and in the vagina of the bitch, respectively [36,38]. In the male dog, the lesions may be accompanied by lochia. This is not observed in the bitch. The virus may be transmitted during copulation, but this route tends to be uncommon [2]. Lesions in the genital tract of the bitch primarily represent a risk of transmission to puppies during birth.

Infection in the respiratory tract of adult dogs

In experimental infections with CHV1, mild symptoms from the upper respiratory tract have been observed [39,40]. An unproductive cough caused by tracheobronchitis has a suggested association with the kennel cough complex. In a two-year study of shelter dogs, coughing was regularly observed [41]. Samples from trachea and lungs revealed CHV1 with some dogs seroconverting three to four weeks after arrival. Conversely, other viral agents were also diagnosed so the exact role of CHV1 in the progression of the disease was unclear.

In another study from two kennels in the UK, dogs were tested for antibodies to corona virus and CHV1 for one year. [42]. In this year two outbreaks of respiratory tract infection coincided with seroconversion against coronavirus, whereas antibodies against CHV1 were detected throughout the year indicating no association with the outbreaks.

Diagnosis

A characteristic history and clinical findings combined with progression of disease are indicative of herpes virus infection in puppies less than two weeks old. In the neonatal period, differential diagnoses include bacterial infections namely sepsis caused by streptococci, staphylococci and coliform bacteria. Diagnosis is based on post mortem findings and the detection of herpes virus or viral DNA in the organs of aborted, stillborn or dead puppies.

Post mortem findings

If neonatal herpes virus infection is suspected, post mortem examination is important for the diagnosis. Characteristic macroscopic findings include multiple haemorrhages in the kidneys, liver, spleen and intestinal serosa (Figure 2 A,B) [1,26]. Congestion and oedema of the lungs is often present. Histopathological examination of stained sections reveals necrotic foci in the parenchyma, often with peripheral haemorrhages (Figure 3 A,B). Intranuclear inclusion bodies may occur in herpes virus infections (Figure 4), but are not always found. If the virus has been transported along the trigeminal or olfactory nerves, degeneration and necrosis of glia cells and neurons may be observed in the cerebellum. Both macroscopic and histological findings may reveal focal necrosis of the foetal part of the placenta.

Virus culturing and detection of viral DNA

Canine renal cells are used for culturing CHV1 in the laboratory [16]. Characteristic degenerative changes develop within days, shown as plaque. Samples from fresh (or frozen) organs are preferred. CHV1 is labile, and post mortem degeneration reduces the chance of virus detection. For culturing cells, the most appropriate course is to sample from dogs with clinical findings. A special transport medium ordered from the laboratory is important for viral detection. A small volume (0.5-1.0 ml) is needed for each sample, and it is worth noting that sample tubes containing charcoal or agar as medium cannot be used. Sample swabs are preferably taken from the mucosa of the nose or the genital tract, depending on clinical findings. The mucosa is cleaned with physiological saline before sampling to reduce the risk of contamination. Samples should be sent fresh and cooled (or frozen to -20°C) by courier to the laboratory. In DNA extracted from organ samples, PCR can be used to detect sequences from the CHV genome [21]. The same method may also be used for detection of viral DNA in formalin-fixed tissue samples [43, 44]. PCR is a robust and technically simpler method than virus isolation, and may be preferred in the future.

Serology

An immune response with production of antiviral antibodies is stimulated in CHV1 infections in puppies older than six to eight weeks and in adult dogs. Two to three weeks after exposure, antibodies may be detected in the serum [2]. An active infection gives an elevation in antibody titre, which remains high for a few months before it declines. A low titre may be detected for several years or may be induced by vaccination. Because the progress of the disease in puppies is acute, neutralising antibodies are seldom detected. During an outbreak, two samples taken from the same dog two to three weeks apart are used to detect a rising antibody titre. Sero-epidemiological studies are used to indicate the prevalence of dogs exposed to CHV1. Several serological methods are used to detect antibodies against CHV in the dog. The immunoperoxidase method has a better sensitivity than the serum-neutralising test, which is regarded as the reference method [47]. It has a high specificity, but a lower sensitivity compared with enzyme-linked immunosorbent assay [5,6,48].

Therapy

In adult dogs, herpes virus infection is asymptomatic, self-limiting and requires no treatment. Limited experience has been acquired with antiviral treatment of herpes virus infection in animals in general [47]. No such drug is licensed for this application in Norway. Aciclovir has been used in cats and horses in some countries. A metabolite of this drug prevents viral DNA synthesis

in cells infected with the herpes virus and only minimally affects normal cell processes in non-infected cells. Aciclovir has poor bioavailability in the dog, but has been used experimentally in the dosage range of 10-20 mg/kg for a week [2,48]. A clinical effect was reported in a case of litter mates of puppies killed by herpes virus infection [48]. Even though antiviral treatment may save some dogs, risks of defects in the central nervous system or myocardium [2] still exist. Common side effects seen in aciclovir overdosage are anorexia and mild gastrointestinal symptoms [49]. Crystals are occasionally found in the kidneys, inducing obstructive nephropathy.

Prophylaxis

Stress and environmental factors

In latently infected dogs, the virus may be reactivated by stress [2]. Breeding dogs should therefore avoid long-distance travel, shows, competitions and stressful activities before mating and during gestation. Other infections may induce reactivation of a latent herpes virus infection, emphasising the importance of the dog's general health. The most common route of transmission is via virus-containing droplets exchanged directly between dogs. Breeding dogs who are not infected should limit contact with risk environments to avoid CHV1 exposure and breeders should maintain good environmental hygiene. Reduced thermoregulation in newborn pups makes them dependant on external heat during the first two weeks of life. Achieving ambient temperatures of about 35-37°C with the aid of a heating lamp and insulating floor is essential. The bitch must also have access to an area of lower temperature to avoid discomfort.

Colostrum

Puppies receive the majority of their maternal antibodies through colostrum and only small amounts are transferred to the fetus in-utero. Colostrum intake within the first hours of life is therefore essential for protection against infections. The permeability of large immunoglobulins through the intestinal mucosa decreases relatively quickly after birth, and therefore puppies should receive adequate amounts of maternal antibodies during the first eight hours after birth. CHV1 infection mostly affects pups from a bitch that had her primary herpes infection during pregnancy. A previously infected bitch has specific antibodies to the herpes virus providing some protection for the puppy during the first couple of weeks. However, if the puppy has no access to colostrum, 1-2 ml of serum from dogs with a high CHV1 antibody titre is reported to have prophylactic effect when administered before virus exposure [50].

Vaccination

A herpes virus vaccine (Eurican® Herpes 205, Merial, France) was registered a few years ago for use against CHV1 infection in dogs in the European Union [51]. This oil-adjuvanted vaccine is not marketed in Norway but is available following application to the Norwegian Medicines Agency. The vaccine contains a surface protein (gB glycoprotein) from CHV1 and antibodies against this antigen neutralise the virus. The vaccine is administered to pregnant bitches providing maternal immunity to the litter during the first two-three weeks of life through the uptake of maternal antibodies in colostrum. The vaccine schedule consists of two doses with an interval of five weeks, the first dose given at mating or some days after, and the second two weeks before the expected whelping. Revaccination follows the same procedure including two doses to secure high levels of protective antibodies in the colostrum. The vaccine has been tested in pregnant bitches at different times of gestation, in experimental studies and in the field [52]. Serious side effects occur rarely. Gestational abnormalities, stillbirth and perinatal mortality were not increased in vaccinated bitches compared to control animals. Local reactions at the injection site are common but reversible. Efficacy studies have been performed in kennels of varying CHV1 infection status [52]. The vaccine was used in pregnant seronegative bitches and in bitches with moderate to high levels of antibodies after natural infection. An increase in antibody titre was seen in the majority of dogs after vaccination, including those which had moderate levels in advance. Vaccination stimulated protective immunity in a study where puppies were challenged with a virulent virus and field observations confirmed experimental findings [53]. In this latter study, the vaccine also had an effect on the survival of fetuses in utero, because vaccinated bitches tended to have a higher pregnancy rate, increased birth weights and lower mortality from birth to weaning.

We consider the herpes virus vaccine as a non-core vaccine which should not be recommended for all bitches [54]. Moreover, vaccination of adult dogs to prevent respiratory tract infection or genital tract lesions is not indicated. The vaccine is recommended only in female breeding dogs with a perceived risk of CHV1 infection to prevent neonatal disease and mortality. The typical family dog living in a household with one or two dogs that has less contact with foreign dogs is probably at lower risk of herpes virus infection compared to one in a multidog household or kennels. Should there be an increased risk of CHV1 infection, especially before mating or during pregnancy, vaccination may be considered. Bitches are at risk if they have been in recent contact with other bitches that have aborted, borne weak puppies, or suffered increased neonatal mortality. Some veterinarians order testing of serum samples for antibodies against CHV1. A seropositive result indicates an earlier infection and a virus carrier status. In these cases, reactivation of a latent virus may occur followed by transmission to fetuses and puppies. It may be difficult to evaluate if antibody titers are sufficiently high to protect the litter. In such cases, one must consider whether vaccination should be performed to increase levels of antibodies in the colostrum.

Discussion

Sero-epidemiological studies indicate that CHV1 infection in dogs is relatively common in several countries. The association between virus infection and neonatal mortality is clear, but under debat where kennel cough is concerned. The importance of CHV1 infection as a cause of infertility, fetal resorption, death and abortion is discussed in several papers. In a Norwegian study of neonatal mortality (stillborns and dead puppies less than eight weeks old) in four large breeds, a mortality rate of 10.9% was reported [55]. The mortality rate for puppies in their

first three weeks of life was 6.9%. Causes of death varied. Few puppies died from "fading puppy syndrome" in the first few weeks of life, with symptoms resembling herpes virus infection. Unfortunately, no further diagnostic investigations were performed.

In a study carried out in Belgium, Ronsse et al studied factors influencing CHV1 antibody levels in kennel dogs [56]. No association was found between antibody levels and gender or breed. On the other hand, a clear relationship existed between antibody levels and age. Dogs less than six months old were seronegative for CHV1 antibodies, whereas several dogs seroconverted from the onset of puberty to two years of age. This was associated with copulation for male dogs but not for bitches, and indicates that venereal transmission occurs in some instances. Dogs from kennels with kennel cough outbreaks had a significantly higher CHV1 antibody titre compared with dogs from kennels without such a history. Additionally, there was a clear relationship between the numbers of dogs in the kennel and antibody levels, as kennels with more than six animals had higher antibody levels than those with fewer dogs. This was more prominent with poor kennel hygiene. In Norway, the most common type of kennel is a small facility with generally good hygiene and few dogs per kennel. This is expected to have a positive influence on the risk of CHV1 transmission between dogs and between kennels. In a prospective field study, Ronsse et al studied antibody levels throughout the reproductive cycle in bitches at 13 kennels [57]. The seronegative bitches seroconverted during the test period but, in one or two test samplings, 40% of the seropositive bitches seroconverted to antibody negative status. This finding indicates how antibody levels vary within the same dog and also underlines the problem of diagnoses based on one sample only. Differences in antibody levels were not observed between stages in the reproductive cycle, but there was a tendency to lower titres during metoestrus. Half of the dogs were mated and infertility (no puppies after mating, fetal resorption or mummification) was observed in 50% of these , however, no conclusions could be drawn regarding the association between CHV1 infection and infertility in this study. Other studies may indicate an association between CHV1 infection and infertility [9,58]. Kennels with few breeding dogs, good hygiene and limited contact with foreign dogs have a lower risk of CHV1 outbreaks than kennels with inferior hygiene conditions. Intense coughing, as seen in kennel cough, can increase the risk of herpes virus infection through droplets if the dog is also infected with the herpes virus. Ronsse et al [56] suggest that vaccination against kennel cough caused by parainfluenza virus and bordetella bacteria can help prevent transmission of the herpes virus. Stress reduction for bitches before mating, during pregnancy and close to parturition helps reduce the chance of reactivation of a latent virus. In kennels with repeated reproductive problems and large neonatel losses, causal evaluation is important. If CHV1 infection is a probable cause, prophylactic regimes as mentioned above may be helpful. Additionally, care of the newborn puppies should include administration of colostrum and provision of optimal environmental conditions. Kennels with endemic CHV1 infections may benefit from vaccination of pregnant bitches. On the other hand, it should be emphasised that immunoprophylaxis must not replace other prophylactic procedures, but supplement them. The nature of the disease, the route of transmission, and the property of latency have persuaded many breeders and veterinarians to live with the virus, simply adding known prophylaxis to reduce the damage of the disease. In areas where CHV1 infection is less common, it may be rewarding to reduce the risk of transmission by reducing travelling and contact with foreign dogs.

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REPRINT PAPER (UK)

A retrospective study of surgically treated cases of septic peritonitis in the cat (2000–2007)

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SUMMARY

Objectives: To review aetiology, clinical signs and outcome of cats surgically treated for septic peritonitis (2000-2007).

Methods: A retrospective study. Inclusion criteria were the identification of intracellular bacteria and degenerate neutrophils and/or a positive culture from abdominal fluid and exploratory coeliotomy. Aetiology, clinical signs, haematological and biochemical parameters, surgical treatment and outcome were recorded and analysed.

Results: Twenty-six cats fulfilled the inclusion criteria. Abdominal pain was reported in 10 (38 per cent) and vomiting was reported in 11 (42 per cent) of the cats. The most common aetiology was trauma (31 per cent). The principal source of contamination was the gastrointestinal tract. Hyperlactataemia, hypoproteinaemia and hyperglycaemia were reported in 9, 13 and 14 of the 26 cases, respectively. Non-survivors had significantly higher blood lactate concentrations than survivors (P=0.02). Nineteen cats were managed with primary closure, two with closed suction drains and three with open peritoneal drainage. Twelve (46 per cent) cats survived to be discharged.

Clinical significance: In cats, lethargy, depression and anorexia were more common clinical signs than abdominal pain. Lactate level at the time of diagnosis may be a useful prognostic indicator in cats. The proportion of cats that survived was lower than previously reported and owners should be given a guarded prognosis.

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Introduction

Septic peritonitis is an often fatal condition encountered in first opinion and referral practice and can occur as a sequel to abdominal surgery. It is characterised by inflammation of the peritoneum secondary to bacterial contamination and infection. It is diagnosed by the identification of intracellular bacteria and degenerate neutrophils within abdominal fluid smears and/or a positive bacterial culture of abdominal fluid [Staatz and others 2002, Connally 2003, Costello and others 2004]. The condition is associated with high morbidity and mortality rates, with survival rates in cats and dogs reported to range between 32 and 80 per cent [Swann and Hughes 2000]. The prognosis in the cat is reported to be comparable to the dog [Costello and others 2004].

With the exception of one study [Costello and others 2004], previous reviews of septic peritonitis have described the clinical signs, aetiology, treatment and outcome in the dog, or dog and cat combined [King 1994, Ludwig and others 1997, Staatz and others 2002]. It is therefore difficult to directly compare the results of these studies. Recent reports demonstrate that cats with severe sepsis often have varying responses and clinical signs to those seen in other species. It is necessary to be aware of these differences to enable early diagnosis and treatment [Brady

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and others 2000]. Rapid diagnosis and surgical treatment are necessary in animals with septic peritonitis to prevent or minimise the progression of hypovolaemia, acid base disturbances and electrolyte abnormalities, all of which will rapidly progress and increase morbidity and mortality [Swann and Hughes 2000].

The history and clinical signs of an animal with peritonitis are often vague and non-specific [Swann and Hughes 2000]. Clinical signs include abdominal pain, vomiting, lethargy/depression, anorexia, polyuria and polydipsia. The principal difference reported by Costello and others [2004] was that only 62 per cent of cats exhibited signs of pain during abdominal palpation. In the dog, septic peritonitis is almost always associated with abdominal pain or discomfort [Swann and Hughes 2000].

The most common source of abdominal contamination in both the cat and the dog is gastrointestinal leakage; in the cat being secondary to underlying neoplasia [Costello and others 2004] and in the dog as a result of surgical wound dehiscence [Hosgood and Salisbury 1988, Costello and others 2004]. Less common aetiologies include trauma and pyogranulomatous disease [Swann and Hughes 2000, Staatz and others 2002, Costello and others 2004]. Costello and others [2004] reported that in 14 per cent of cats the underlying cause of the septic peritonitis was not identified during surgery or postmortem examination which is in contrast to the situation in the dog.

To the authors' knowledge the study by Costello and others [2004], which included 51 cats, is the only large study that has been performed focusing primarily on the cat. Their study represented a population of cats in the USA and included all cats diagnosed with septic peritonitis based on cytological evaluation, microbial culture or postmortem examination findings. Not all of the cases reported underwent surgical exploration and treatment. Data regarding the aetiology, clinical signs and outcome of cats surgically treated for septic peritonitis are therefore sparse. It is also possible that population and management differences between the UK and USA may result in different features of the condition to those previously identified. The aims of the study reported here were to review the aetiology, clinical signs, outcome and prognosis of cats diagnosed with and surgically treated for septic peritonitis and to identify differences between previous reports on the cat and dog. Results will assist in the early diagnosis and treatment of the condition, thereby increasing the chance of survival.

Materials and Methods

Medical records of cats referred to the Royal Veterinary College, London, that were diagnosed with septic peritonitis between February 2000 and February 2007 were retrospectively reviewed. Criteria for inclusion in the study were the identification of intracellular bacteria and degenerate neutrophils within abdominal fluid smears and/or a positive culture from peritoneal fluid in association with an exploratory coeliotomy. Management of individual cats was at the attending clinician's discretion. Cats in which septic peritonitis was suspected based only upon compatible clinical signs and history were excluded.

Clinical records

The following information was accrued: breed, age, sex, date of admission, clinical signs and rectal temperature at the time of diagnosis, aetiology, haematological and biochemical parameters (see below), details of any previous related surgery, details of the surgical treatment performed (peritoneal lavage with primary closure, open peritoneal drainage or closed peritoneal drainage), initial antibiotic and fluid therapy, postoperative nutritional support (that is, placement and type of feeding tube), bacterial culture and sensitivity, histopathology results and clinical outcome.

Aetiology of septic peritonitis was assigned to one of the five groups: traumatic, neoplastic, iatrogenic (including previous surgery), miscellaneous and unknown. The source of bacterial contamination was identified and recorded.

When available from the medical records, selected haematological and biochemical parameters from blood taken at the time of diagnosis of septic peritonitis were recorded. Variables recorded were lactate, total protein (TP), albumin, glucose, neutrophil and band neutrophil counts. Due to the small sample size and non-Gaussian distribution, median values and ranges of the measured biochemical and haematological values from the whole study population were calculated.

Cats were classified as either "survivors" or "non-survivors." Survivors were defined as cats that survived to discharge. Non-survivors included cats that died or were euthanased. When available, the reason for euthanasia was recorded.

Statistical analysis

Descriptive analysis was performed. Data were assessed for normality using a Shapiro-Wilk's test (SPSS 14 for windows, LEAD Technologies Inc., USA). Where appropriate, further statistical analysis was performed using SPSS 14 for windows (LEAD Technologies Inc., USA). Ninety-five per cent confidence intervals (CI) of selected variables were calculated. Due to the small sample size and non-Gaussian distribution of the data, non-parametric tests were used. Comparison of data recorded between the "survivors" and "non-survivors" groups was performed using the Mann-Whitney U test and Fishers exact test methods for continuous and discrete variables, respectively. A value of $P \leq 0.05$ was considered significant.

Results

Signalment

Twenty-six cats fulfilled the requirements for inclusion in the study (Table 1). Breeds represented were domestic shorthair (DSH) (15), domestic longhair (DLH) (1), Persian (4), Burmese (3), Siamese (1), Bengal (1) and Maine Coone (1). There were 14 neutered males and 12 neutered females, with an age range of 6 months to 15 years (median age three years). Eighteen of the 26 cats were less than five years old.

Clinical signs

Lethargy/depression was observed in 25 cats [93 per cent (95 per cent CI=74-100 per cent)], anorexia in 21 cats [81 per cent

Table 1. Breed, age (years), sex, aetiology, source of contamination, overview of surgical management and outcome of cats included in the study

Breed	Age (years)	Sex	Aetiology	Source of contamination	Surgical management	Outcome
DSH	2	NM	Trauma – RTA resulting in gastric rupture	Stomach	Open drainage	Died
DSH	1	NM	Trauma – shot with air rifle	External penetration and small intestine	Abdominal lavage and primary closure	Survived
DSH	0.5	NM	Trauma – dog bite	External penetration	Abdominal lavage and primary closure	Survived
DSH	1	NF	Trauma – dog bite	External penetration and stomach	Abdominal lavage and primary closure. Oesophageal feeding tube	Died
Persian	3	NM	Trauma – shot with air rifle	External penetration and small intestine	Abdominal lavage and primary closure	Survived
					Naso-oesophageal feeding tube	
Burmese	7	NM	Trauma – RTA resulting in biliary tract rupture	Biliary tract	Euthanasia	Euthanasia
DSH	2.5	NF	Trauma – dog bite	External penetration	Open drainage. Oesophageal feeding tube	Euthanasia
DSH	0.75	NM	Trauma – shot with air rifle	External penetration and small intestine	Abdominal lavage and primary closure	Euthanasia
DLH	14	NF	Iatrogenic – enterotomy dehiscence	Small intestine	Abdominal lavage and primary closure	Survived
DSH	1	NF	Iatrogenic – enterotomy dehiscence	Small intestine and colon	Abdominal lavage and primary closure	Survived
Bengal	4	NM	Iatrogenic – gastrostomy tube migration	Stomach	Abdominal lavage and primary closure	Died
DSH	1	NM	Iatrogenic – enterotomy dehiscence	Small intestine	Abdominal lavage and primary closure	Survived
DSH	3	NM	Iatrogenic – enterotomy dehiscence	Small intestine and colon	Abdominal lavage and primary closure. naso-oesophageal feeding tube	Survived
Persian	3	NM	Iatrogenic – enterectomy dehiscence	Small intestine	Abdominal lavage and primary closure	Euthanasia
DSH	3.5	NF	Miscellaneous – intussusception	Small intestine	Abdominal lavage and primary closure	Euthanasia
Burmese	5	NF	Miscellaneous – ruptured para-cystic abscess. Abscess surrounding dorsal and left aspect of bladder, urethra and ureters	Abscess	Placement of closed abdominal suction drain. Oesophageal feeding tube	Survived
DSH	0.9	NF	Miscellaneous – secondary to cholecystitis and ruptured gall bladder	Biliary tract	Abdominal lavage and primary closure	Survived
Persian	10	NF	Miscellaneous – perforated gastric ulcer	Stomach	Abdominal lavage and primary closure. Oesophageal feeding tube	Survived
Burmese	0.8	NM	Miscellaneous – perforated gastric ulcer	Stomach	Abdominal lavage and primary closure	Survived
DSH	16	NM	Miscellaneous – ruptured duplex gall bladder	Biliary tract	Abdominal lavage and primary closure	Euthanasia
Persian	13	NF	Neoplasia – gastric perforation (leiomyosarcoma)	Stomach	Abdominal lavage and primary closure	Euthanasia
Siamese	15	NF	Neoplasia – gastric perforation (carcinoma)	Stomach	Abdominal lavage and primary closure	Euthanasia
DSH	8	NM	Neoplasia – duodenal perforation (adenocarcinoma)	Small intestine	Abdominal lavage and primary closure. Naso-oesophageal feeding tube	Euthanasia
Maine Coon	4	NM	Unknown	Undetermined	Euthanasia	Euthanasia
DSH	4	NF	Unknown	Undetermined	Open drainage	Euthanasia
					Oesophageal feeding tube	
DSH	0.75	NF	Unknown	Undetermined	Placement of closed abdominal suction drain. Gastrostomy feeding tube	Survived

DSH Domestic shorthair; DLH Domestic longhair; NM Neutered male; NF Neutered female; RTA, Road traffic accident

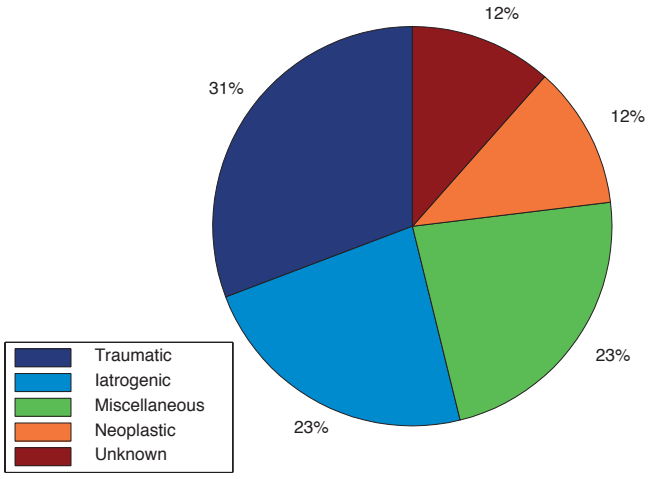
(95 per cent CI=51-100 per cent)], abdominal pain in 10 cats [38 per cent (95 per cent CI=14-75 per cent)], vomiting in 11 cats [42 per cent (95 per cent CI=5-80 per cent)] and ascites in 9 cats [35 per cent (95 per cent CI=0-71 per cent)]. Rectal temperature at the time of diagnosis ranged from 33.8 to 41.0°C (Median 38.5°C). Nine cats were considered hypothermic (less than 38.2°C) and four were considered hyperthermic (greater than 39.0°C).

Aetiology

The aetiology and hence the underlying nature of contamination was identified in 23 of the 26 cats included in the study (Table 1). The aetiologies were categorised as follows; eight traumatic, six iatrogenic, six miscellaneous, three neoplastic and three unknown (Fig 1). Traumatic causes included gun-shot wounds (three), bite wounds (three) and road traffic accidents (two). All cases with iatro-genic peritonitis were as a result of complications from previous surgery performed at first referring veterinary practices. Three cats had dehiscence of small intestinal enterotomy sites and one had dehiscence of a colonic enterotomy site following foreign body removal. One cat had breakdown of a small intestinal end-to-end anastomosis site following removal of a foreign body and in one cat a previously placed gastrostomy tube migrated allowing leakage of gastric contents into the abdomen. Intestinal leakage secondary to adenocarcinoma (one), leiomyosarcoma (one) and invading pancreatic carcinoma (one) were seen in three cats. The miscellaneous causes included spontaneous gastroduodenal perforation (two), gall bladder rupture (one), gastrointestinal leakage secondary to an intussusception (one), a ruptured para-cystic abscess (one) and peritonitis secondary to cholecystitis and a ruptured gall bladder (one).

The nature of the contamination was classified as due to leakage of gastrointestinal contents (including biliary tract) in 16 cats, inoculation of infection via a penetrating injury in one cat, leakage of purulent fluid from an abscess in one cat and both a penetrating injury and leakage of gastrointestinal contents in five cats. In the three cats with unknown aetiology there was no obvious primary focus of infection or disruption of intra-abdominal viscera.

FIG 1. Aetiologies of cases of septic peritonitis.



Haematology and biochemistry

Biochemistry at the time of diagnosis of septic peritonitis was available for 17 (65 per cent) to 19 (73 per cent) of the cases (depending on parameter of interest) (Tables 2 and 3). Hyperlactataemia, hypoproteinaemia and hyperglycaemia was observed in 9 (n=19), 13 (n=16) and 14 (n=19) of the cases, respectively (where n equals the number of cases for which the biochemical parameter was available). There was a statistically significant difference between measured blood lactate when comparing survivors and non-survivors (P=0.02) with median lactate at the time of diagnosis of septic peritonitis being 1.4 mmol/l (range 0.4-6.0 mmol/l) and 3.5 mmol/l (range 1.1-10..7 mmol/l) in the survivors and non-survivors, respectively. There was no statistically significant difference between measured total protein (P=0.84), albumin (P=0.54) and glucose (P=0.32) when comparing survivors and non-survivors.

A neutrophilia was observed in nine cats, and a neutropaenia was observed in two cats (Table 2). There was no statistically significant difference between neutrophil count when comparing survivors and non-survivors (P=0.36)(Table 3). Thirteen cats had the presence of increased number of band neutrophils documented (Table 2).

Microbial culture

Gram-negative enteric organisms were identified in 12 out of 13 cats that had a bacterial culture performed [Escherichia coli (nine cases), *Enterococcus faecalis* (two cases) and *Pasteurella* (one case)]. In one cat *Corynebacterium* species was cultured.

Intraoperative findings and surgical management

At the time of surgery, 19 cats were managed with copious abdominal lavage and primary closure (Table 1). Two cases were managed with a closed suction drain (Jackson Pratt type drain) and three with open peritoneal drainage. Feeding tubes were placed in nine cats following surgery; naso-oesophageal (three), oesophageal (five) and gastric (one).

Two cats were euthanased at the time of surgery. In one case the cause of the septic peritonitis could not be identified and in view of the poor prognosis the owner elected for euthanasia. In the second case ruptured hepatic ducts were identified. The owner declined further treatment due to the cat's clinical condition and poor prognosis.

Unfortunately, there were insufficient animals in treatment groups to draw pertinent conclusions on the association between treatment methods and outcome.

Antibiotics and fluid therapy

All cats received perioperative and postoperative intravenous fluids and antimicrobials at the attending clinician's discretion. All cats received crystalloids (Hartmann's solution). Eight cats received colloids. Of those, three cats received oxyglobin (Biopure Cor-poration, USA) and two received oxyglobin as well as a blood transfusion. None of the cats receiving oxyglobin or blood transfusions survived to discharge. Of the three cats that were administered pentastarch, one survived to discharge.

Table 2. Biochemical and haematological parameters from the whole study population

	Mean value	Standard deviation	Median	Range	Reference range
Glucose (mmol/l) n=19	8.6	3.8	7.6	2.4-14.9	4.2-6.6
Lactate (mmol/l) n=19	3.1	2.7	1.9	0.4-10.7	0.6-2.5
Albumin (g/l) n=17	23.8	6.5	21.0	16-39	28-42
Neutrophils (×109/l) n=19	17.7	14.1	10.7	0.6-47.2	2.5-12.5
Bands (×109/l) n=13	2.6	2.2	1.8	0.5-6.3	0-0.3
Total protein (g/l) n=16	54.2	9.9	52.5	40.3-73.5	61-80

Median values and ranges of the measured biochemical and haematological values are presented along with parameter reference ranges

Table 3. Biochemical and haematological parameters for survivors and non-survivors

		Survivors			Non-survivors		
	Reference range	n	Median	Range	n	Median	Range
Glucose (mmol/l) n=19	4.2-6.6	9	9.5	3.7-14.6	10	7.2	2.4-14.9
Lactate (mmol/l) n=19	0.6-2.5	9	1.4	0.4-6	10	3.5	1.1-10.7
Albumin (g/l) n=17	28-42	7	22.4	17.2-39	10	21.0	16-39
Neutrophils (×109/l) n=19	2.5-12.5	9	8.7	2.1-35.2	10	17.8	0.6-47.2
Bands (×109/l) n=13	0-0.3	5	4.9	0.56-6.29	7	0.92	0.5-3.8
Total protein (g/l) n=16	61-80	7	51	40.3-73.5	9	54	42.1-71.2

Median values and ranges of the measured biochemical and haematological values are presented along with parameter reference ranges

At the time of diagnosis various antimicrobials were used either alone or in combination: cefuroxime (14), metronidazole (13), enrofloxacin (10), amoxicillin/clavulanate (5) and ampicillin (18). Continuation of antibiotic therapy was based on culture and sensitivity results with antibiotics being stopped or changed following test results.

Outcome

Survival to discharge occurred in 12 of the 26 cats (46 per cent). Median duration of hospitalisation for survivors was seven days (range 4-20 days). Fourteen of the 26 cats died, which included 11 that were euthanased. All cases where euthanasia was performed were reported to have been due to deterioration of the cat's condition. None were reported to have been euthanased due to financial reasons. No statistical difference was observed when comparing survival of cats with septic peritonitis originating from traumatic or iatrogenic causes (P=0.59).

Discussion

Results from this study suggest that the prevalence of clinical signs seen in cats with septic peritonitis differ to those seen and previously reported in the dog [Swann and Hughes 2000]. Abdominal pain and vomiting, which are typically seen in dogs with peritonitis, were observed in only 10 and 11 cats, respectively (43 and 48 per cent). This is also less than the 62 per cent previously reported in the cat [Costello and others 2004]. Lethargy/depression and anorexia were more consistent findings, being seen in 96 and 82 per cent of cats, respectively. These clinical signs are non-specific to the condition of septic peritonitis. Variability between the frequencies of specific clinical signs observed in this study to that reported previously may in part be due to differences in case inclusion criteria. Here, we included only cases of septic peritonitis that were surgically treated. Abdominal pain and vomiting may be more commonly observed in patients that do not survive to become surgical candidates. It is however important to note that the absence of vomiting and abdominal pain should not be used to rule out the diagnosis of septic peritonitis in the cat. It is also important to note that the variability in the frequencies of clinical signs reported here compared with other studies could be due to the small sample size. The presented 95 per cent CIs demonstrate that the differences could be due to random variation and chance due to the small sample size.

This is the first study where trauma has been identified as the most common primary cause of septic peritonitis, responsible in 8 of the 23 cats (35 per cent). Trauma has previously been reported as the underlying aetiology in only 16 per cent of animals [Costello and others 2004]. The most common cause previously reported was gastrointestinal tract (GIT) leakage as a result of neoplasia in the cat [Costello and others 2004], and as a result of surgical wound dehiscence in the dog [Hosgood and Salisbury 1988, Swann and Hughes 2000]. Similar to previous studies in both the cat and the dog, the primary source of abdominal contamination in our population was from GIT leakage [Hardie and others 1986, Swann and Hughes 2000, Costello and others 2004]. The inclusion of only surgical cases in this study may have resulted in a reduction in the number of cases that were reported to be secondary to neoplasia. A diagnosis of neoplasia may have influenced the decision to elect for surgical treatment, hence excluding the case from the study. The difference in reported underlying aetiologies may also go some way to explaining the difference in clinical signs observed when comparing studies.

In the study by Costello and others [2004], the median age of the cat population was five years. In our study the median age of the cats was three years with 17 cats (74 per cent) being

under five years of age. This small age difference may partly explain the differences seen in aetiologies when comparing studies. Behavioural differences of a younger population may increase the risk of trauma. It is interesting to note that in three cats the cause of septic peritonitis remained unidentified despite extensive investigation. Septic peritonitis of unknown origin has previously been described in the cat [Mueller and others 2001, Costello and others 2004], and has recently been reported in the dog [Culp and others 2009]. It may be that bacterial translocation from the GIT could trigger peritonitis. However, in the three cases described, there was no evidence of underlying GIT pathology.

Consistent with previous studies, serum glucose concentration at the time of diagnosis was variable [King 1994, Costello and others 2004]. Hyperglycaemia was the most common finding. This may have been a result of a stress response. Blood glucose patterns are also influenced by the time course of the infection [Miller and others 1980, Hardie and others 1986]. There was no significant difference between glucose levels when comparing survivors and non-survivors. It has previously been reported that the blood to peritoneal fluid glucose concentration ratio is a reliable diagnostic indicator of septic peritoneal effusion in the cat [Bonczynski and others 2003]. Unfortunately, due to the retrospective nature of our study peritoneal fluid glucose levels were not available for any of the cats.

A statistically significant difference was identified when comparing blood lactate between survivors and non-survivors, with measured lactate being higher in the non-survivor group. This suggests that lactate level at the time of diagnosis may be a useful prognostic indicator. In human medicine blood lactate is used as a prognostic indicator for critically ill patients [Bakker and others 1991]. Hyperlactaemia has also been associated with a higher mortality rate among dogs in an intensive care unit [Lagutchik and others 1998]. Interestingly, Levin and others [2004] identified that in the dog peritoneal fluid lactate concentration and blood to fluid lactate differences are accurate tests for detecting septic peritoneal effusions. This relationship was not however demonstrated in the cat. Unfortunately, in our study peritoneal fluid lactate levels were not available for any of the cats and this relationship could therefore not be examined.
Hypoalbuminaemia is a common finding in cats with sepsis [Brady and others 2000] and was observed in 14 of 17 cats where bio-chemistry results were available. Fluid therapy before diagnosis of septic peritonitis may have resulted in decreased albumin values in some cats. This would vary between individuals due to management variation between cats. Hypoalbuminaemia in animals with septic peritonitis can also result from a series of pathophysiological mechanisms including increased loss of albumin into the abdominal cavity [Brady and others 2000].

In the present study Gram negative enteric organisms were identified in all but one of the cats where culture was performed. This reflects the high incidence of gastrointestinal rupture as an underlying cause and is consistent with previous studies [Hardie and others 1986, Swann and Hughes 2000, Staatz and others 2002]. In one case *Corynebacterium* species was cultured. Despite careful and thorough physical examination and surgical exploration, the source of contamination remained undetermined. This bacterium can be found in the oral mucosa of cats [Gruffydd-Jones 1991] suggesting a cat bite could have been a possible underlying cause.

The overall mortality rate in this study was 54 per cent. This does fall within the range previously reported of 20-68 per cent [Swann and Hughes 2000], however is greater than that of more recent studies in the cat [Costello and others 2004]. Cats that were euthanased due to septic peritonitis were classified as having died of septic peritonitis, as the proportion of euthanased animals in the study sample was so high, omitting these would have resulted in an extremely small sample size. Limitations of this method are acknowledged [Hosgood and Scholl 2001]. Due to the retrospective nature of the study it was not possible to accurately classify reasons for euthanasia further (that is, such as disseminated intravascular coagulation and systemic inflammatory response syndrome), as information required for such classification was not available from the records. Neoplasia was identified in three of the cases of septic peritonitis. The outcome in these cases would likely have been partly determined by the underlying neoplasia of the condition and not by sepsis alone. This should therefore be considered when interpreting overall survival rates presented in this study.

As with all retrospective studies, interpretation of the data is complicated by the large number of variables that cannot be controlled including, variability in management both before and upon admission to the hospital, the absence of haematology and biochemistry from some cats and the timing of euthanasia. Euthanasia can be affected by a combination of factors including disease progression, financial constraints, the owner and the veterinarian and so bias can be introduced. None of the cats included were reported to have been euthanased due to financial reasons. In all cases the reported reason for euthanasia was due to a grave prognosis and/or failure to respond to therapy. A prospective study would be helpful to examine and control for these varying factors; however, septic peritonitis is a multi-faceted condition and does not lend itself well to this type of study. Our study is also limited by the small number of cats. This is expected given the nature of the condition. The small sample size allows only the detection of large differences between survivors and non-survivors. Small differences present in this study may therefore result in type II statistical errors. It is important to note the differences in inclusion criteria of cats included in our study when comparing our results to the only other large study of septic peritonitis in the cat [Costello and others 2004]. In their study, only 23 out of 51 cats had surgery, which was our criterion of inclu-sion. This, as well as other differences discussed, demonstrates the difficulty of comparing results from multiple studies.

In conclusion, our results reveal that the survival rate in this group of cats with septic peritonitis was 46 per cent. Clinical presentation of septic peritonitis differed from that previously reported in both cats and dogs, with fewer cats exhibiting pain on abdominal palpation. In contrast to previous studies, trauma was the most common aetiology. If septic peritonitis is confirmed the cat owner should be given a guarded prognosis.

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REPRINT PAPER (D)

Objective interpretation of dental disease in rabbits, guinea pigs and chinchillas

Use of anatomical reference lines

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INTRODUCTION

Objective: Objective interpretation of dental disease in rabbits, guinea pigs and chinchillas with the use of anatomical reference lines.

Material and methods: Skull radiographs (laterolateral and dorsoventral view) of 528 small mammals (204 rabbits, 151 guinea pigs and 173 chinchillas) were measured and analysed exactly in connection with a thorough intra- and extra-oral clinical examination. 464 animals showed variable signs of malocclusion whereas 64 animals had a normocclusion. The clinical and radiographic changes of 224 individuals (52 rabbits, 41 guinea pigs and 131 chinchillas) were additionally compared with post mortem findings.

Results: Particularly the comparison of the prepared skulls with the radiographs of the identical animals enabled the acquirement of species specific anatomical reference lines, that facilitate the objectice assessment of the severity of dental disease in elodont species.

Conclusion and clinical relevance: Using these reference lines the extent of malocclusion in rabbits, guinea pigs and chinchillas can be acquired more exactly and the results are reproducible by different examiners (staging). In addition to this these special lines facilitate to accurately monitor the progress of dental changes and thus to predict a probable long-term prognosis. The reference lines are absolutely applicable for daily use in practice.

Key words Malocclusion, normocclusion, radiography, assessment, long-term prognosis, staging

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Introduction

Dental diseases in rabbits and rodents are very common and often pose a challenge for the attending veterinarian. In this context, there have been numerous publications within the last two decades describing species pathological changes seen in the different species [1–45]. Many of these point out the importance of a thorough radiographic examination of the skull using multiple views and give some helpful advice on the treatment, but they rarely describe objective methods to ascertain the degree of pathological changes such as tooth elongation. Thus it has not been possible to accurately monitor the progress of these changes. This paper, however, illustrates a range of radiographic anatomical landmarks for the examination of rabbits, guinea pigs and chinchillas. With the help of these landmarks specific reference lines can be defined which enable the veterinarian to discern the specific pathological changes and perform accurate measurements for long-term monitoring if necessary. Use of these anatomical reference lines greatly simplifies explanation of oral problems to the animal's owners, as they can clearly see the extent of changes. This permits them to better understand the treatment recommendations and any associated complications.

A specific reference line which demonstrates extraoral maxillary

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Radiographic Examinations				
	Rabbit	**Guinea pig**	**Chinchilla**	**Total animals**
With dental disease	183	132	149	464
Clinically healthy	21	19	24	64
Totals	204	151	173	528
Post mortem Examinations				
	Rabbit	**Guinea pig**	**Chinchilla**	**Total animals**
Skull dissection	52	41	131	224

Table 1 Radiographic (laterolateral and dorsoventral view each) and post-mortem examinations

		Rabbit	**Guinea pig**	**Chinchilla**
Lateral projection	Dorsal limitation of maxillary tooth apices (white line)	Proximal end of the nasal bone to occipital protuberance	Rostral end of the nasal bone to dorsal notch of the tympanic bulla (about three quarters of its height)	Dorsal margin of the maxillary incisor to middle of the tympanic bulla
	Occlusal plane (yellow line)	Rostral end of the hard palate to one third of the height of the tympanic bulla	Rostral surface of the mandibular incisor (normal length) to the notch of the tympanic bulla (about three quarters of its height)	Tip of the upper incisors to the tympanic bulla (about three quarters of its height)
	Ventral limitation of mandibular tooth apices (blue line)	No penetration of the ventral mandibular cortex	No penetration of the ventral mandibular cortex	No penetration of the ventral mandibular cortex
	Mismatch of the cheek tooth arcade (reliable sign of significant malocclusion) (red lines)	No regularity	Rostral displacement of the mandible	Caudal displacement of the mandible
Dorsoventral projection	Lateral limitation of the maxillary tooth arcade	Lateral margin of the maxillary first incisor's tip to medial edge of the mandibular ramus	Mesial border of the maxillary incisor to the most caudolateral part of the ipsilateral mandible	Medial tip of the maxillary incisor to caudal extremity of the ipsilateral mandibular ramus
	Medial limitation of the maxillary tooth arcade	Lateral rim of the contralateral maxillary incisor to the lateral border of the tympanic bulla	–	–

Table 2 Reference lines (overview)

cheek tooth elongation (apical intrusion) in chinchillas was published by Crossley in 1995 and 1996 [8, 10]. Five years later, Boehmer mentioned a similar basic reference line for rabbits and guinea pigs [1]. These three lines turned out to be so helpful in objectively illustrating extra-oral maxillary cheek tooth problems on laterolateral radiographs that studies were extended to include dorsoventral views. On the basis of numerous measurements performed on radiographs of 528 lagomorphs and rodents with and without pathological dental changes (Table 1), additional reference lines were acquired (Table 2).

The reference lines presented in this paper represent those that have survived validation by clinical and radiographic follow-up plus post-mortem examinations performed on previously radiographed patients (Table 1).

Radiographic screening

Whilst the presence of some dental problems can be determined by physical examination, the bulk of the teeth is embedded in the jaw. In order to detect whether or not a rabbit, guinea pig or chinchilla suffers from tooth elongation or other changes in dental morphology, it is best to initially obtain two radiographic views of the skull (laterolateral and dorsoventral). These screening views can normally be achieved using light sedation. It helps to

obtain the laterolateral view with the mouth open a couple of millimetres as separation of the cheek teeth improves definition of the occlusal line. Additional views are usually indicated after screening but positioning for these is more complicated, so they are best obtained once the animal is fully anaesthetised [1, 2]. When obtaining radiographs after placement of an endotracheal tube in rabbits, its location has to be taken into consideration as superimposition over the area of interest can obscure anatomy and pathological changes. Therefore the use of injectable anesthetic agents should be prefered. The technical requirements for an adequate radiographic examination of the skull and hints for an optimal positioning in different species had been described in detail in a previous two-section paper [1, 2].

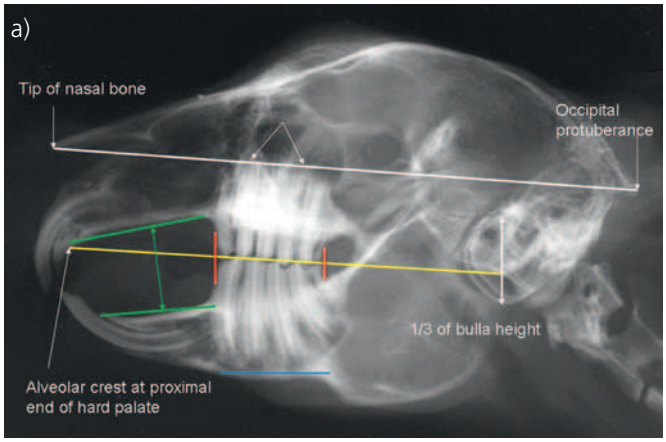
Rabbit

Normal radiographic anatomy of the skull

In clinically healthy animals no dental structure should extend dorsal to a reference line that connects the proximal end of the nasal bone with the tip of the occipital protuberance on the lateral view (Fig. 1a). In rabbits without pathological changes of the skull or teeth, another reference line runs parallel to the one previously mentioned, beginning at the rostral end of the hard palate (yellow line) mostly immediately caudal to the second incisor and extending caudally to pass through the tympanic bulla at approximately one third of its height. This line matches the occlusal plane in healthy rabbits. Although in this species six maxillary cheek teeth occlude with five mandibular ones, the maxillary and mandibular dental arcades are approximately the same length (red lines in Fig. 1a). Additionally, the apices of the mandibular cheek teeth should not penetrate the ventral mandibular cortex which should have a near even thickness beneath the first three cheek tooth apices (blue line). Remodelling of the ventral cortex adjacent to the tooth apices indicates that there is retrograde elongation of the lower cheek teeth. Furthermore the palatine and mandibular bone plates should slightly converge rostrally in normal rabbits (green lines in Fig. 1a) the amount of convergence varying somewhat with breed skull type.

There are also some relevant reference lines on the dorsoventral view of the skull which add to the information obtained from lateral views. The first line connects the lateral margin of the maxillary first incisor's tip with the medial edge of the mandibular ramus on the same side caudally. Another line, which diverges slightly from the previous one, runs from the lateral border of the tympanic bulla to the lateral rim of the contralateral maxillary

Fig. 1 Radiographic anatomic reference lines of a clinically healthy rabbit. See main text for explanation. a) Laterolateral view; b) dorsoventral view; c) intraoral radiograph of the maxilla.



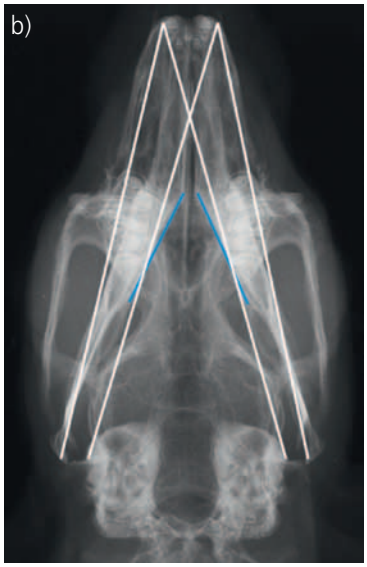
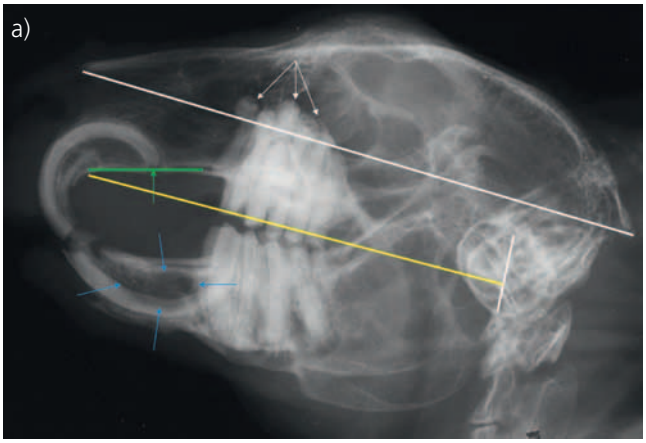
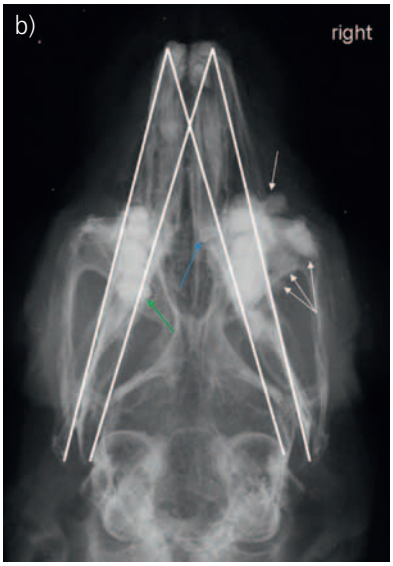


Fig. 2 Rabbit, 8 years, advanced stage of dental disease. See main text for explanation. a) Laterolateral view; b) dorsoventral view.





incisor (Fig. 1b). With the exception of the tips of the apices of the significantly curved maxillary second and third cheek teeth (see arrows in Figure 1c), no part of any tooth should be located outside these two lines. The two blue lines in Figure 1b indicate the medial cortex of the mandible. This should be almost straight, smooth and even. The maxillary premolar anatomy is shown in Figure 1c without superimposition of the mandible and its associated teeth.

Dental disease

The applicability of these anatomical reference lines is demonstrated in Figures 2 and 3 which show radiographs of two rabbits with advanced dental disease. In Figure 2a, a distinct retrograde apical elongation of multiple maxillary cheek teeth can be seen, as indicated by the white arrows. Additional findings are a malocclusion of the incisor teeth with penetration of the palatal bone cortex by the apex of at least one of the maxillary first incisors (green arrow). There is also considerable bone loss in the mandibular incisor region suggestive of an intra-bony abscess (blue arrows).

Even if laterolateral radiographs are imperfectly positioned the reference lines can be approximated and remain valid as shown in Figure 2a. Although the second reference line in yellow cannot be drawn as precisely, it still shows that the occlusal plane is close to normal rostrally, but there is slight elongation of the clinical crowns of the maxillary molars.

The dorsoventral view of this rabbit (Fig. 2b) objectively demonstrates pathological changes of the maxillary cheek teeth. The retrograde root elongation is distinctly seen to be primarily affecting the right side. Both the lacrimal and maxillary zygomatic processes have been deeply penetrated and overlain by the intruded root apices of elongated teeth. All but the last maxillary cheek tooth of this side show laterally displaced apices which are more radiodense than normal and have lost the normal apical structure. On the left side, the maxillary second molar is displaced medially (Fig. 2b, green arrow). On the right side the medially displaced apex of the mandibular first cheek tooth (premolar 1), is also seen (Fig. 2b, blue arrow).

Examination of the laterolateral and dorsoventral views in this case indicate that, as in many cases, additional radiographs are required for more accurate localization of the pathological changes. At least two oblique views (right and left side mirror image views) plus an intraoral image of the mandible are required in this case to ascertain whether the mandibular first cheek tooth is involved in the lesion affecting the mandibular incisor.

The reference lines drawn in Figure 3a highlight the distinctly intruded apices of the maxillary cheek teeth in another rabbit. The second to fourth maxillary cheek teeth (premolar 2 to molar 1) are affected (white arrows). In addition, the bony part of the lacrimal duct is pathologically distended (red arrow) and the palate is remodelled to accommodate the intruding apices of the maxillary first incisors (green arrow). The occlusal plane is uneven and there is a significant mismatch in its length between maxilla and mandible (red lines). In addition to this, a deformity of one of the mandibular second cheek teeth can be seen, accompanied by a broadening of the caudal interdental space (blue arrow), despite superimposition of the two sides.

The dorsoventral view (Fig. 3b) illustrates a distinct penetration of the zygomatic and lacrimal processes by marked retrograde tooth elongation of four teeth on the left side (white arrows) whilst just three maxillary cheek teeth are affected on the right (green arrows). The yellow arrows indicate a medial displacement of the apices of the first and second mandibular cheek teeth (right side). Care is required in order to distinguish radiographically between intermandibular retrograde tooth displacement (yellow arrows) and intraoral lingual spur formation (blue arrow) so a thorough intraoral examination is essential at the same time as radiography. As with the previous case, an intraoral mandibular and two oblique radiographs are indicated to further distinguish the pathology.

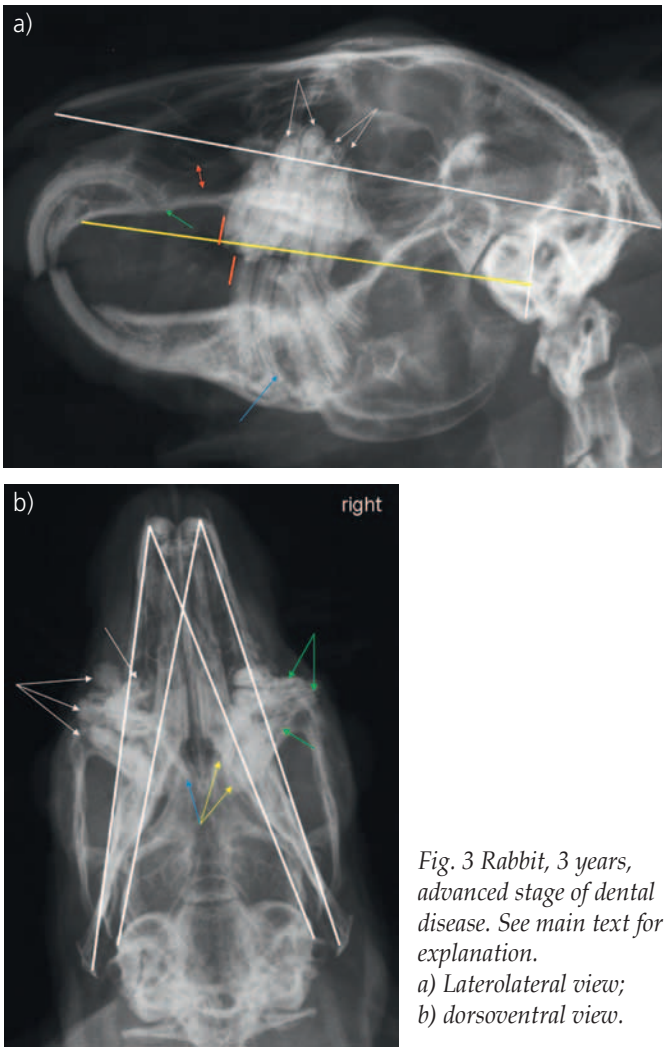


Fig. 3 Rabbit, 3 years, advanced stage of dental disease. See main text for explanation.
a) Laterolateral view;
b) dorsoventral view.

Guinea Pig

Normal radiographic anatomy of the skull

Anatomical reference lines are also useful in guinea pigs. One connects the rostral end of the nasal bone with the dorsal notch of the tympanic bulla, about three quarters of the height of the bulla (Fig. 4a). In young guinea pigs the nasal bone forms a nearly straight line with the dorsal skull (orange line), whereas in older guinea pigs the two meet at a slight angle creating a dorsal concavity where they meet (orange line in Figures 5a and 6a).

As the occlusal surfaces of guinea pig cheek teeth are strongly

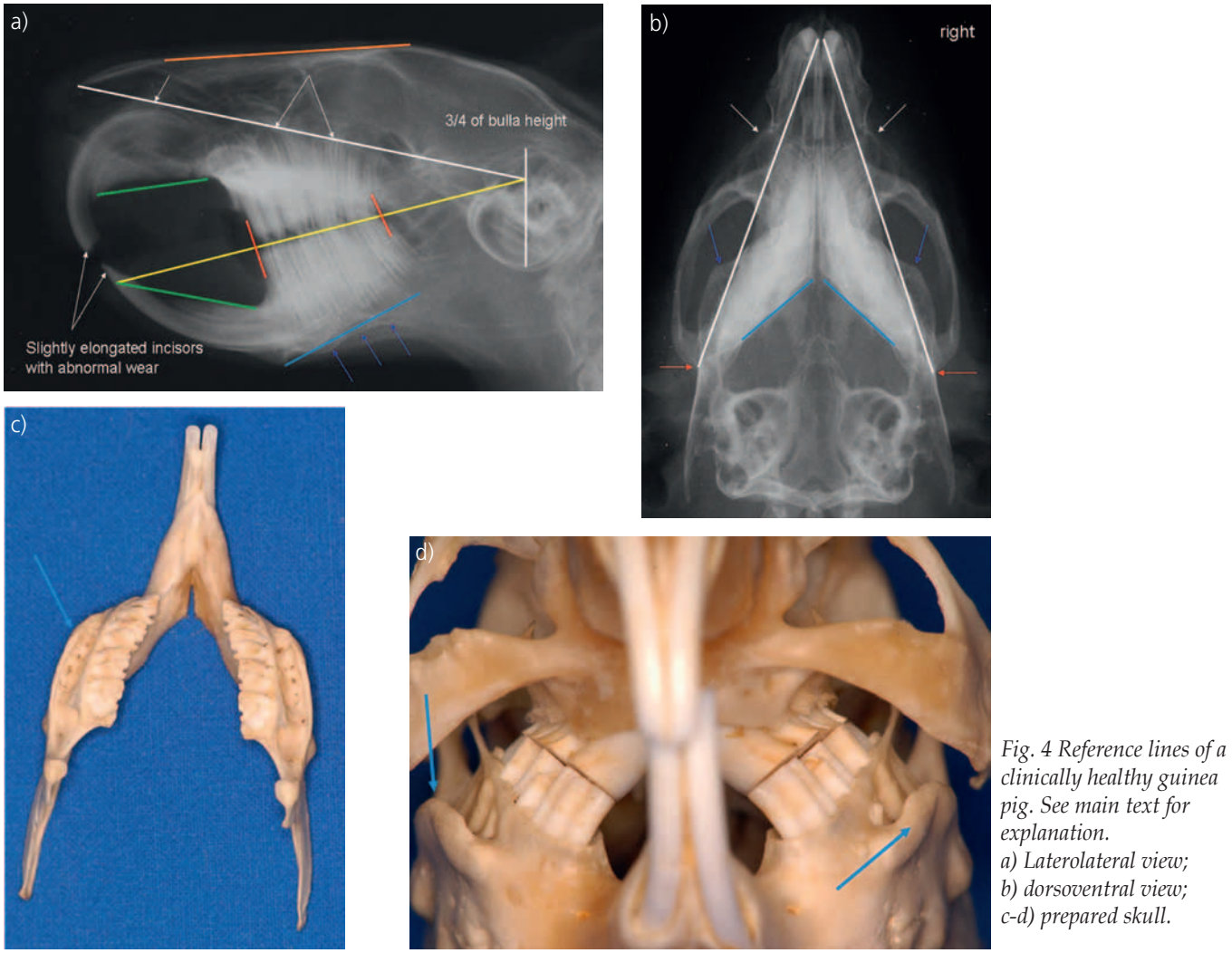


Fig. 4 Reference lines of a clinically healthy guinea pig. See main text for explanation.
a) Laterolateral view;
b) dorsoventral view;
c-d) prepared skull.

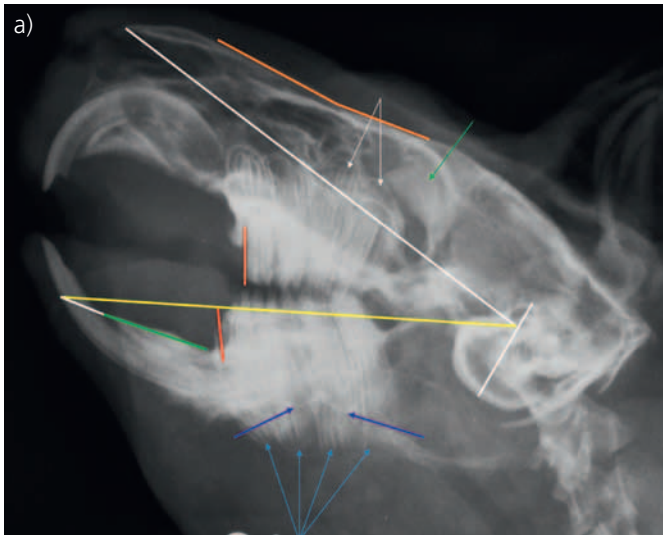
angled the occlusal plane does not present as a clear line on the laterolateral skull view (certain vagueness because of superimposition of the medial occlusal part of the upper and the lateral occlusal part of the lower cheek teeth), but it is mostly sufficiently visible to allow comparison with the next reference line. This is drawn from the point on the rostral surface of the mandibular incisor where it is crossed by a line projected cranially from the mandibular bone plate (green line), to the notch of the tympanic bulla (yellow line in Fig. 4a). This second reference line runs straight along the occlusal line of the mandibular cheek teeth. If the teeth are truly healthy it should also run through the wear surfaces of the maxillary and mandibular incisors when the mouth is closed, but this is rarely seen in practice as most guinea pigs have at least a minor degree of clinical crown elongation as seen in this case.

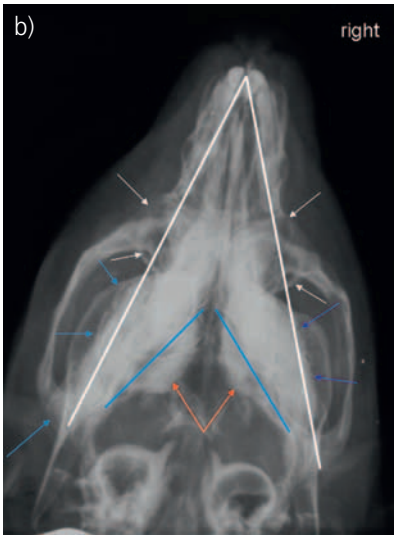
As in rabbits, the ventral mandibular cortex (blue line) should not be penetrated by any of the cheek tooth apices which should be distinctly radiolucent. If thinning, distortion or penetration is evident (dark blue arrows), retrograde tooth elongation is present. The guinea pig's oral profile differs from that of rabbits, the palatal and mandibular cortices converge noticeably rostrally when the mouth is closed (green lines). The greater the degree of intraoral tooth elongation the less obvious this becomes in guinea pigs. The maxillary and mandibular tooth arcades are each formed by four cheek teeth, the maxillary and mandibular arcades being of matching lengths (red lines). A discrepancy between arcade lengths is an indicator of significant dental problems in this species.

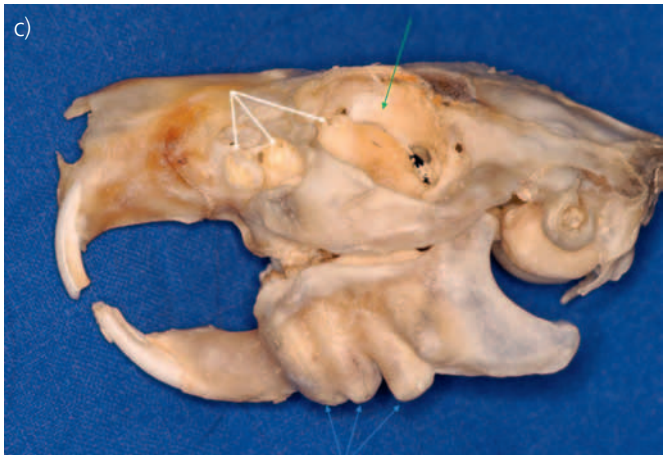
On the dorsoventral skull view the most informative reference line runs from the mesial border of the maxillary incisor to the most caudolateral part of the ipsilateral mandible, which lies at the level of the temporal zygomatic process (red arrows in Fig. 4b). In guinea pigs without any significant tooth elongation only the radiolucent apical bulla of the maxillary first cheek tooth (the premolar) extends beyond this line (white arrows). More caudally the prominent nearly crescent shaped bone structure crossing this line (blue arrows in Figures 4b, c and d) is the masseteric ridge of the mandible, where the deep part of the masseter muscle originates. The blue lines in Figure 4b indicates the medial cortical borders of the mandibles.

Dental disease

A mature guinea pig (see the angulation in the orange line) with advanced dental changes is shown in Figures 5a to 5d. The dorsal reference line clearly demonstrates a retrograde displacement of the reserve crown and apices of the third and fourth maxillary cheek teeth (white arrows in Fig. 5a). Dorsocaudal to that area, the radiograph of the skull shows radiodense bone formation that is clearly seen on the dissected skull from this animal (green arrow in Figures 5a and 5c).







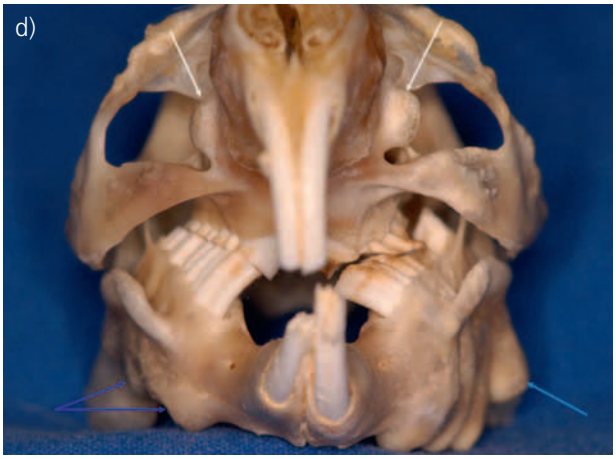
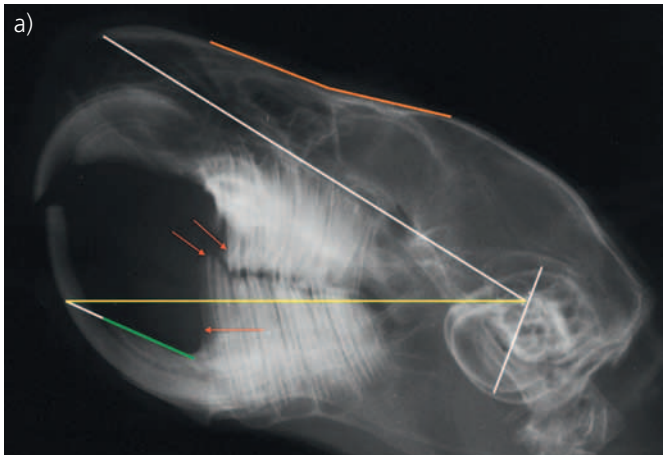


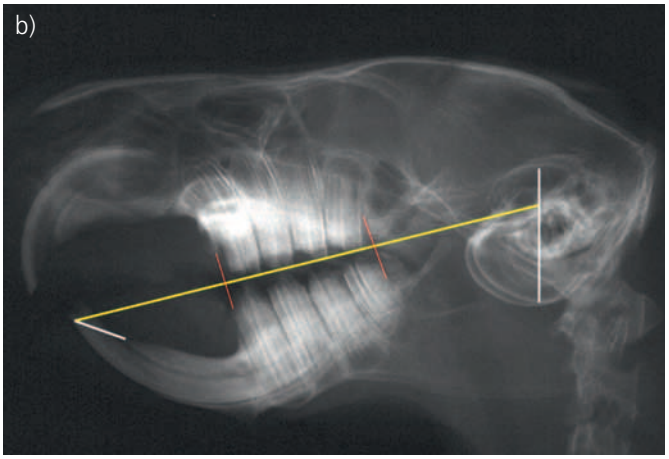
Fig. 5 Guinea pig, 4 years, advanced stage of dental disease. See main text for explanation. a) Laterolateral view; b) dorsoventral view. An incidental finding on this dorsoventral view is thickening of the bone of the left tympanic bulla. c) Skull lateral view of the left side; d) rostrocaudal view.

The rostral point of origin for the second reference line is less precise in this animal due to changes in the mandibular bone plate and rostral tipping of the incisors; however, the line clearly shows an intraoral elongation of the mandibular molars (yellow line). Additionally the apexes and reserve crowns of all the cheek teeth on one side have penetrated the ventral mandibular cortex demonstrating marked apical elongation (light blue arrows in Figures 5a, c and d). Superimposed over this, cortical thinning and remodelling is clearly seen around the apices of the teeth in the other mandible (dark blue arrows in Figures 5a and d). Mismatch of the cheek tooth arcade lengths is clearly visible (red lines in Figure 5a). This is a very reliable sign of significant dental disease, particularly in this species. The mouth can clearly be seen to be in the fully open position in this animal as the rostral mandible and palate are almost parallel.

On the dorsoventral view (Fig. 5b) the reference lines reinforce

Fig. 6 Guinea pig, 7 months, early stage of dental disease. See main text for explanation. a) Laterolateral view before; b) immediately after trimming the teeth.



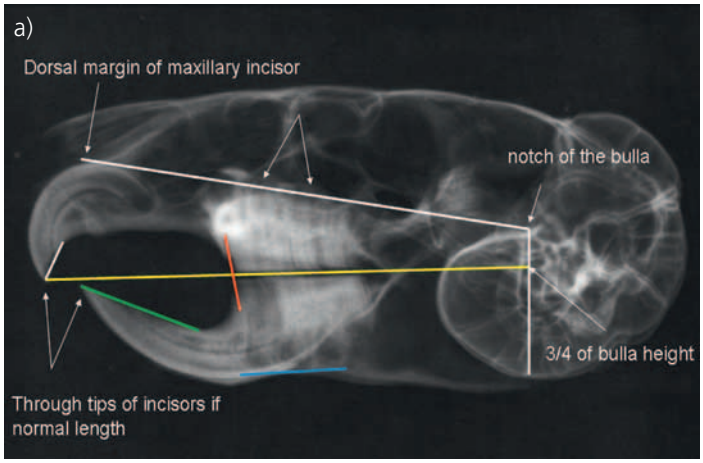


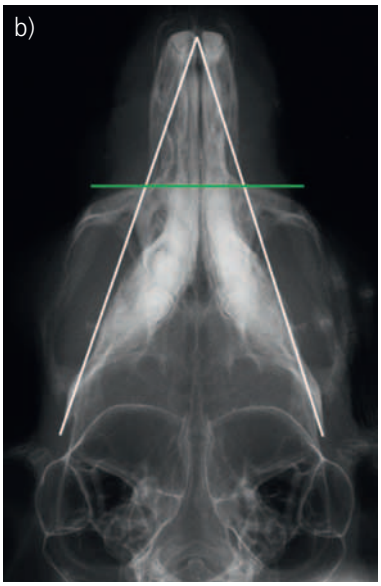
the findings from the lateral view: a distinct and generalized retrograde displacement of the reserve crowns and apices of both the mandibular and maxillary cheek teeth is evident (left side > right side). The elongated mandibular molar apices extend beyond the reference line laterally (light and dark blue arrows). The apices and elongated reserve crowns of the maxillary premolar and first molar also cross the reference line in the area of the infraorbital canal (white arrows in Figure 5b), with penetration of the bone cortex on the left side as confirmed from the dissected skull of this guinea pig (white arrows in Figures 5c and 5d). The light blue arrow in Figure 5d points at the mandibular left fourth cheek tooth which has extreme retrograde elongation and deviation. The second reference line along the medial cortex of the mandible, represented by the blue lines in Figure 5b, is crossed medially by some tooth substance (red arrows). This correlates with a combination of probable rostral displacement of the mandible, as occurs accompanying intraoral tooth (clinical crown) elongation in many guinea pigs, and the overlong reserve crowns of the caudal maxillary molars of both sides.

The anatomical reference lines can be very helpful in interpreting post-treatment radiographs. As mentioned above, it is typical for the mandible to be forced rostrally in guinea pigs with intra-oral tooth elongation (Fig. 6a). The yellow reference line in Figure 6a shows that the animal's lower cheeck teeth are far too long. Extensive shortening and recreation of normal occlusal angulation is necessary for all the mandibular teeth including the incisors, the maxillary teeth then requiring occlusal adjustment to match the mandibular teeth. The goal of treatment is to reach as near to normal occlusion as possible.

In this case the teeth were elongated without other significant changes so the teeth could be returned to near normal as shown by the reference line in Figure 6b. Following tooth trimming, the occlusal plane is at near normal height and the maxillary and mandibular tooth arcades are opposite each other and of approximately the same lengths. Critically judged the lower incisors are still a bit too long (white line) and miss typical chisel-shaped tips. Despite a good dental outcome such animals will have some problems chewing in the post-treatment period as the jaw muscles take time to readapt to a shorter working length during which time supportive feeding may be required.

Fig. 7 Reference lines in a healthy chinchilla. See main text for explanation. a) Laterolateral view; b) dorsoventral view.





Chinchilla

Normal radiographic anatomy of the skull

The most important reference line in chinchillas connects the dorsal margin of the maxillary incisor with the middle of the tympanic bulla, which is very large in chinchillas (Fig. 7a). In healthy animals the radiolucent soft tissue at the apices of the maxillary cheek teeth should be on this line, with no calcified tooth structures extending dorsal to it. As most pet chinchillas have retrograde displacement of the cheek tooth apices, it is uncommon to find animals without any abnormalities here.

The second reference line begins at the tip of the upper incisors and extends caudally to pass through the tympanic bulla at approximately three quarters of its height. It runs almost parallel to the palatinal bone and passes through the occlusal surfaces or tips of both the incisors when they are of normal length and occlusion (yellow line in Fig. 7a). This position will need to be estimated in a manner similar to finding the point of origin on the rostral surface of the mandibular incisor in guinea pigs if the teeth are significantly elongated (green line). The reference line (yellow) coincides with the normal occlusal plane. Due to the physiology of normal chewing the occlusal plane should be horizontal and quite even in this species, resulting in a distinct straight line on laterolateral radiographs of clinically healthy chinchillas.

The third reference line runs near parallel to the occlusal line extending caudally from the most ventral part of the mandibular incisor and corresponds with the ventral mandibular cortex below the apices of the first three cheek teeth (blue line). The ventral border of the mandible should be smooth and even without any thinning or distortions associated with intruded apices.

Reference lines on the dorsoventral view are not as accurate in identifying changes as those for guinea pigs, but are still useful. Lines can be drawn between the medial tip of each maxillary incisor and the caudal extremity of the ipsilateral mandibular ramus (white lines in Figure 7b) to mark the lateral limit of cheek teeth in clinically healthy animals. A transverse line drawn through the points where the first lines cross the rostral edge of

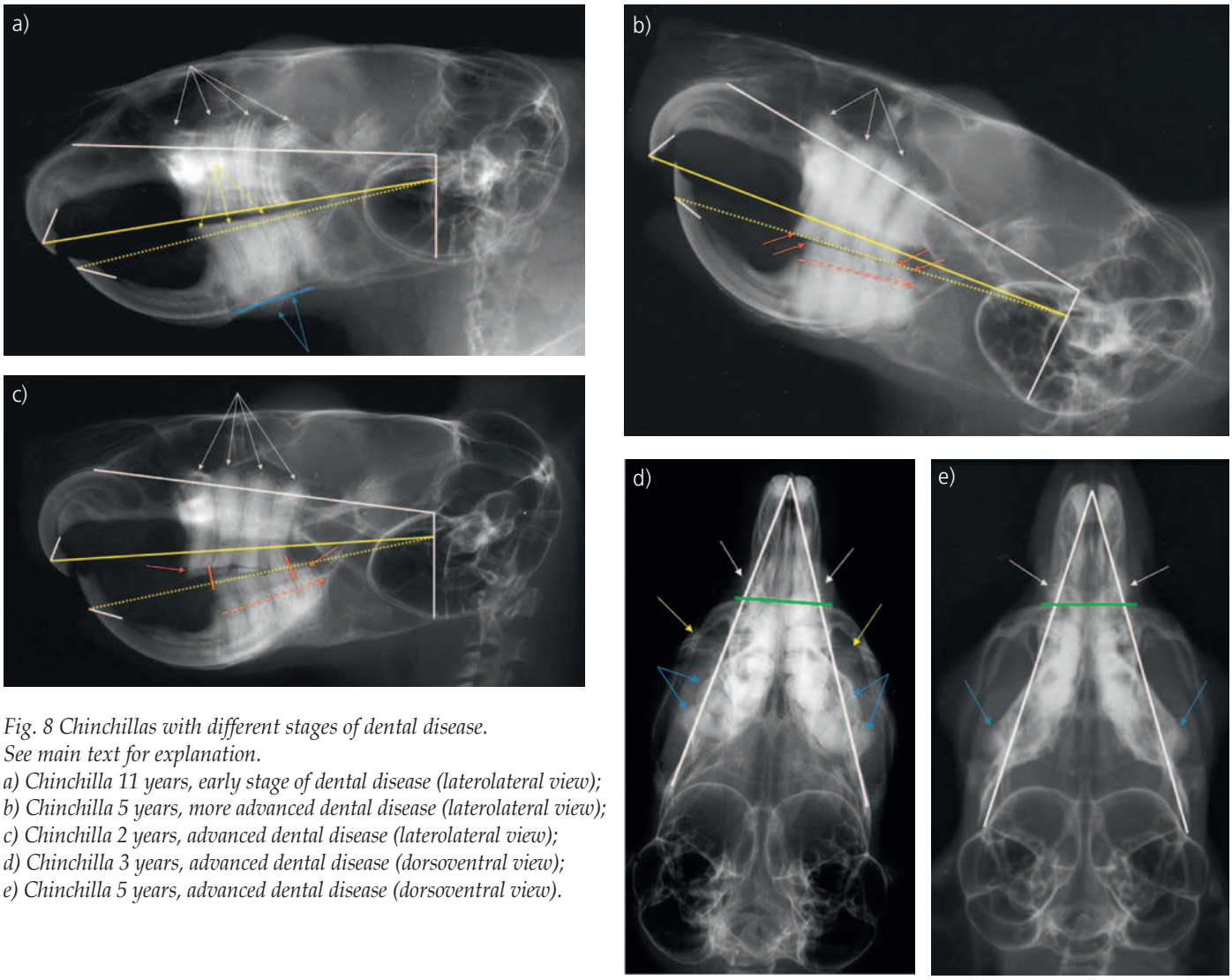


Fig. 8 Chinchillas with different stages of dental disease.
See main text for explanation.
a) Chinchilla 11 years, early stage of dental disease (laterolateral view);
b) Chinchilla 5 years, more advanced dental disease (laterolateral view);
c) Chinchilla 2 years, advanced dental disease (laterolateral view);
d) Chinchilla 3 years, advanced dental disease (dorsoventral view);
e) Chinchilla 5 years, advanced dental disease (dorsoventral view).

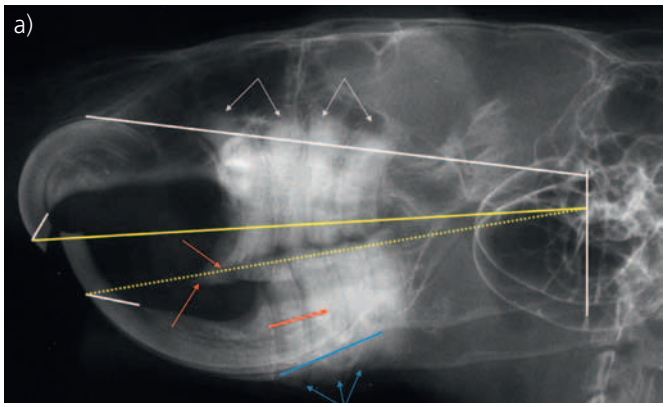
the maxillary zygomatic processes (green line Figure 7b) indicates the most rostral extent of clinically healthy cheek tooth apices.

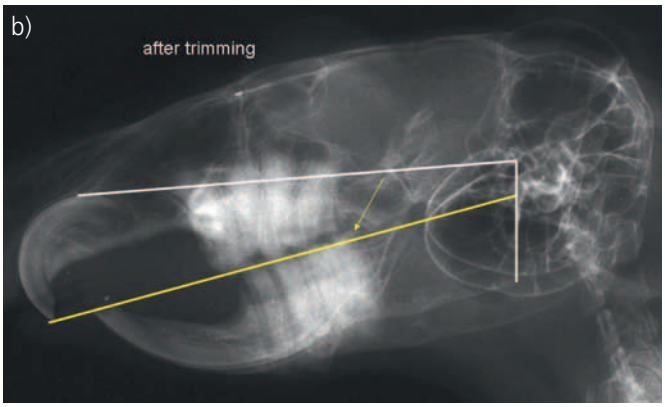
Dental disease

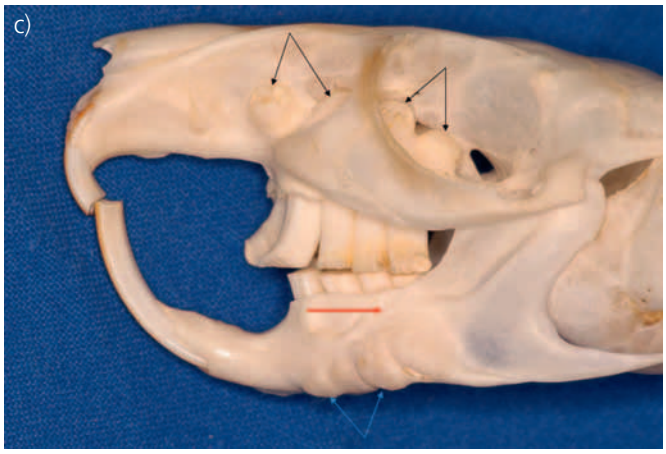
Although the radiograph in Figure 8a does not show major pathological changes, the reference lines clearly indicate that there is significant change present in this chinchilla. The upper line demonstrates an advanced stage of retrograde tooth elongation of all the maxillary cheek teeth (white arrows). The mandibular molar clinical crowns are elongated (broken yellow line and yellow arrows in Figure 8a) and need to be shortened. In order to be able to determine the correct rostral end of both yellow lines the length of the upper and lower incisors has to be corrected first (white lines – compare with Figure 7a). Note that the increased divergent curvatures rostrally and caudally have elongated the occlusal surfaces. The ventral cortex of the mandible is penetrated by the apices of the second and third cheek teeth (blue arrows). As such apical changes cannot be reversed, ongoing dental problems are expected even if the occlusal surfaces are returned to normal alignment.

Contrary to the situation in guinea pigs with dental disease, where the lower jaw moves rostrally, the mandible typically shifts caudally in chinchillas. This is scarcely visible in Figure 8a. Chinchillas with this incongruity have significant dental problems, the degree of mandibular displacement closely correlating with the extent of clinical crown elongation. It represents the combined effects of tooth curvatures and the resultant "open mouth" jaw alignment due to clinical crown elongation. The dental arcades are often displaced by as much as half (red arrows in Figure 8b) or even the whole width of a cheek tooth (red arrows in Figure 8c).

Dorsoventral views often permit easy detection of changes in dental morphology which can be clearly seen as irregularities of tooth structure and alignment. The blue arrows in Figures 8d and 8e point at the intruded apices of the caudal mandibular molars. The white arrows mark the apices of the first two maxillary cheek teeth (premolars) which extend beyond the rostral reference line. Typically, they elongate in an arc and penetrate the maxillary bone in this area, obstructing or obliterating the nasolacrimal ducts. It is important to distinguish clinical crown from apices on this view: the yellow arrows in Figure 8d indicate the intraorally and buccally elongated first cheek tooth on both sides in this animal. The clinical crowns appear more lucent compared with the intra-alveolar parts of the cheek teeth which appear relatively radiodense, being surrounded by alveolar bone and soft tissues.







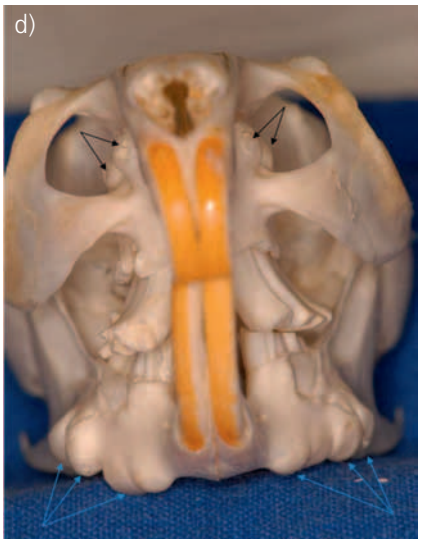


Fig. 9 Chinchilla, 6 years, advanced dental disease. See main text for explanation. a) Laterolateral view before and b) immediately after trimming the teeth; c) left lateral view of the dissected skull one year later, d) rostrocaudal view.

As in guinea pigs, the reference lines permit checking for correct shortening of the cheek teeth. Figure 9a shows the laterolateral view of a chinchilla with excessive intra- and extra-oral tooth elongation. The two yellow lines approximate the normal occlusal lines and clearly indicate how much tooth substance has to be removed (area in between the lines). This is up to one third of the maxillary tooth substance. The corresponding reference line on the post treatment image (Fig. 9b) shows that the shortening was not entirely successful. The last mandibular molar is still somewhat too long (yellow arrow), but in general the occlusion is much better. It is often difficult to remove sufficient length of tooth as the gingiva has usually grown to cover part of the elongated clinical crowns, so repeated occlusal adjustment should be scheduled before there is further significant elongation to make further adjustments. In cases with gross clinical crown elongation it is preferable to stage treatment, only removing about two third of the measured excess tooth length initially, scheduling completion of treatment 2–3 weeks later. This permits better muscle re-adaptation to the shorter working length and gives time for the gingiva to recede exposing enough crown for more effective occlusal correction.
As the animal had to be euthanized a year later, the dissected skull of this chinchilla was examined (Figs. 9c and 9d). This demonstrates the generalized intra- and extra-oral elongation of all teeth along with the associated bony changes that were evident on the previous radiographs: retrograde displacement of all the maxillary cheek tooth apices, the accompanying maxillary bone penetration (black arrows), apparent caudal dislocation of the mandible (red arrow) and the ventral distension of the mandibular cortex (blue arrows).

Conclusion

Anatomical reference lines adapted to the particular anatomy of the species enable the veterinarian to more accurately assess and evaluate aspects of dental disease in rabbits, guinea pigs and chinchillas. Reference lines provide an objective measure of tooth elongation which can be demonstrated to owners, permit assessment of prognosis, appropriate treatment planning and assessment of success of treatment for clinical crown elongation. They make it easier for veterinarians to help their elodont patients.

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REPRINT PAPER (B)

Long-term follow-up after arthroscopic tenotomy for partial rupture of the biceps brachii tendon

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SUMMARY

Objective: To report long-term clinical outcome and radiographic results in dogs diagnosed with partial bicipital rupture and treated by arthroscopic tenotomy.

Materials and methods: The medical records of dogs that had undergone arthroscopic tenotomy were retrospectively reviewed. Inclusion criteria for this study were: performance of an arthroscopic tenotomy between August 1999 and July 2007, availability of arthroscopic records data for review, and ability to obtain follow-up data for more than 1 year after arthroscopic tenotomy. In all cases, owners were interviewed at re-check appointments or via telephone to determine perceived outcome after surgery.

Results: Forty-seven arthroscopic tenotomies were performed on 40 dogs without any major surgical complications. Long-term follow-up examinations ranging from 12 months to 48 months (mean 26 months) after the tenotomy were obtained for 24 dogs (25 shoulders). Clinical outcome was excellent in 22 shoulders (88%), with each dog showing a full return of limb function. A total of 10 dogs (11 joints) were evaluated radiographically and revealed no progression of pathology in 6 joints (55%). Five joints (45%) showed a limited progression of pathology radiographically.

Conclusion: Arthroscopic tenotomy in the treatment of bicipital tendon partial rupture yields favourable long-term clinical results and a high degree of owner satisfaction. The feasibility of this technique and the long-term clinical and radiographic outcome from our study indicate that this technique can be considered a reliable and safe treatment for partial bicipital rupture.

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Introduction

Tendon and ligament conditions are becoming more frequently recognised as a cause of shoulder lameness [1-5]. According to Bardet [5], the most commonly reported conditions affecting the bicipital tendon are partial or complete tears at its origin. The aetiology of partial or complete ruptures and the associated tenosynovitis is complex [6-9].

The disease occurs primarily in large or medium-sized dogs of middle-age or older. Clinical signs are usually chronic and progressive [9-11].

Typical clinical findings are a positive biceps test and, when a complete bicipital rupture is present, hyperextension of the elbow along with flexion of the shoulder [1]. Diagnostic imaging for a partially or completely ruptured biceps tendon includes radiography, arthrography, ultrasonography and arthroscopy. Primary radiographic signs are changes at the supraglenoid tubercle, such as osteophytosis, osteosclerosis, a radiolucent area and deformation of the tubercle and calcification and osteophytosis within the tendon sheath. Secondary arthrosis develops with chronicity of the lesion [11]. Confirmation of the

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diagnosis can be made with ultrasound showing a changed structure of the proximal part of the biceps tendon as well as defects or a complete rupture. An increased amount of fluid within the tendon sheath is often seen as a secondary sign of synovitis within the joint [12- 13]. Arthrography can also be used to confirm the diagnosis by demonstrating a changed delineation of the biceps tendon and its sheath [14-16]. Arthroscopy allows direct inspection of the biceps tendon, showing thickening of the tendon, ruptured fibres and hyperplastic remnants [17-18]. Recently, MRI has shown great potential as a diagnostic tool in the evaluation of canine shoulder disease, including partial bicipital rupture [19]. A correct diagnosis is crucial for obtaining the desired treatment result.

The stabilising function of the biceps tendon in the shoulder remains controversial therefore treatment varies widely among surgeons, ranging from non-operative management to bicipital repair, tenotomy or tenodesis. Surgical treatment is recommended for dogs that do not respond to medical treatment. According to the veterinary literature, good and excellent result have been obtained with both tenotomy and tenodesis [20-22], however, the ultimate outcome was based on preliminary results and long-term clinical results are unavailable. The purpose of this study is to evaluate the long-term clinical outcome and radiographic results in dogs diagnosed with partial bicipital rupture treated by arthroscopic tenotomy.

Materials and methods

Inclusion criteria

The medical records of dogs that underwent arthroscopic tenotomy as treatment for partial rupture of the biceps tendon (PRB) were retrospectively reviewed. Inclusion criteria for this study were: performance of an arthroscopic tenotomy between August 1999 and July 2007, availability of arthroscopic records data for review, and ability to obtain follow-up data for more than 1 year after the arthroscopic tenotomy.

For this study, diagnosis of PRB was based on the presence of definitive forelimb lameness localised to the shoulder, filling defects of the biceps brachii tendon sheath, abnormal delineation of the tendon seen on a positive contrast arthrogram or an amorphous, inhomogeneous, hyperechoic biceps brachii tendon on ultrasonographic examination and confirmed by arthroscopy. Retrieved data included, age, gender, breed, activity status, orthopaedic examination findings, arthroscopic findings and follow-up examinations.

Arthroscopy

Shoulder arthroscopy was performed in a standardised manner for all dogs using craniolateral and caudolateral portals (Wolf 2.7 mm, 30° fore-oblique arthroscope) (Richard Wolf GmbH, Knittlingen Germany) [18]. The joint was explored using a standard compartmental approach. The presence of a partial bicipital rupture was assessed by visual examination and probing the tendon while extending and flexing the elbow. Transection of the tendon was achieved by an arthroscopic hook scissor (Richard Wolf Gmbh, Knittlingen, nr. 98487.04). At the time of arthroscopy, digital images of each structure were obtained for subsequent evaluation and data recording.

Post-operative care

The instructions for initial post-operative care that were given to owners included short leash walks, or restriction of the dog to a small room when unobserved, for 6 weeks after surgery. In addition, analgesics were administered for 3 weeks however physiotherapy was not performed. When there was no evidence of pain at the 6 week re-check, a progressive return to full activity and non-concussive activities were encouraged over the subsequent 6 weeks. Unrestricted activity was allowed after 12 weeks of convalescence.

Outcome

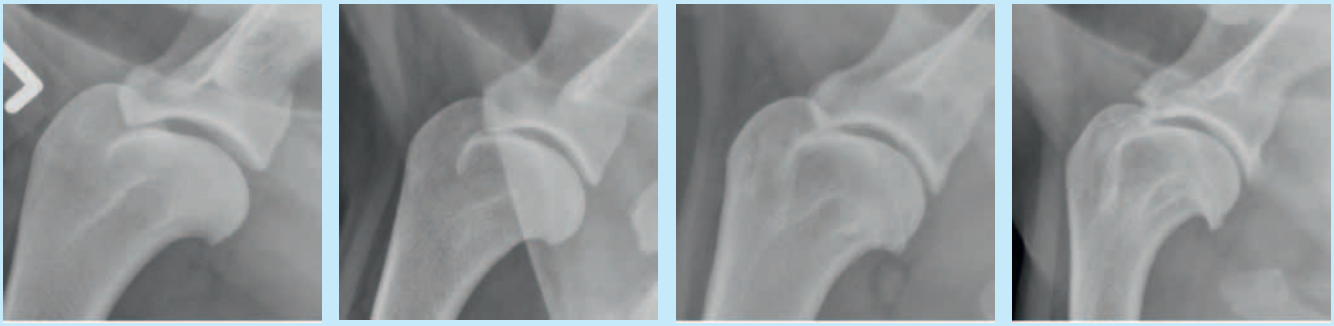
In order to evaluate the treatment outcome the owners were asked to present their dogs for a clinical and radiological re-examination (Group 1). If the owners could not present the patient to the clinic again the treatment was evaluated by means of functional results reported by the owner through a questionnaire (Group 2). The extent of the remaining complaints and complications were of special interest. All of the dogs presented were observed and video recorded walking and trotting on leash, in a straight line and in a circle (2 directions). Two investigators independently assigned an individual lameness score for each forelimb of each dog. The lameness score was based on a 5-point scale: 0 = no detectable lameness, 1 = mild weight-bearing lameness, 2 = moderate weight-bearing lameness, 3 = marked weight-bearing lameness, 4 = non-weight-bearing lameness. The evaluation of the treatment's success was based on the findings of the clinical examination and on the owners' reports (questionnaires). The outcome was rated 'excellent' when no lameness was observed or reported in all activities without the use of anti-inflammatory medication. The outcome was rated 'good' in dogs with occasional lameness or exercise intolerance sensitive to anti-inflammatory medication. All other outcomes were rated 'poor'. Radiographs from the initial examination and the follow-up examination were evaluated and compared with respect to subchondral bone sclerosis, remodelling, osteophytosis and enthesiophytosis. The joint was then subjectively graded based on the severity of the radiographic arthrosis (Fig. 1).

Results

Patients

47 arthroscopic tenotomies were performed in 40 dogs, but only 24 dogs met the inclusion criteria due to lack of follow-up. Nine dogs were no longer living at the time of owner contact and so no interview was performed. Contact data were not available for 7 other dogs because of address change. All of the dogs were large breed and included: Bernese Mountain Dog (7), Newfoundland (2), Golden Retriever (3), Border Collie (3), Crossbreed (2), Rottweiler (1), American Staffordshire Terrier (1), Labrador Retriever (1), German Shepherd (1), Irish Wolf Hound (1), Beauceron (1), and Nova Scotia Duck Tolling Retriever (1). The dogs' ages ranged from 6 months to 10 years (mean: 42 months). The group included 10 intact females, 1 spayed female, 9 intact males, and 4 castrated males.

Figure 1. Joints with PBR with different degree of arthrosis



Grade 0 *Grade 1* *Grade 2* *Grade 3*

Grade 0: No radiographic abnormality
Grade 1: Sclerosis at the glenoid rim and medial trochlea of the biciptal sulcus
Grade 2: Osteophytosis less than 3mm at the caudal rim of the humeral head
Grade 3: Osteophytosis more than 3 mm at the caudal rim of the humeral head

Clinical and arthroscopic findings

The degree of lameness varied among the dogs (n=24), ranging from subtle, chronic intermittent lameness to permanent non–weight-bearing lameness. The duration of lameness ranged from 3 weeks to 3 years (mean: 3.5 months). Only in half of the cases, was there a history of trauma and acute onset of lameness. Orthopaedic examination findings include, atrophied shoulder muscles (92%), a painful shoulder in extension (20%), a positive biceps test (88%) and hyperextension of the elbow (8%). Besides the ruptured aspect of the biceps tendon, the most consistent arthroscopic findings were synovial hypertrophy and hyperaemia (88%) and fibrillation of the medial glenohumeral ligament (32%). Other findings included fibrillation of articular cartilage of the humeral head (12%), fibrillation of the subscapularis muscle (8%) and a partial rupture of the medial glenohumeral ligament (4%).

Outcome and radiographic evaluation

Long-term follow-up examinations were obtained for 24 dogs (25 shoulders) and ranged from 12 months to 48 months (mean: 26 months). No complications related to the tenotomy were reported. The follow-up exam consisted of a second clinical and radiological examination of the affected dogs (Group 1; n= 10 dogs (11 shoulders)) or a questionnaire answered by the patient's owner (Group 2; n=14 dogs (14 shoulders). In Group 1, 81% (9/11) showed an excellent result, with relief of symptoms at a mean time of 3 weeks. The dogs had no abnormalities on clinical examination, were without lameness at the time of the long-term follow-up examination, and did not show any signs of lameness after exercise. The result for one dog was rated as 'good' (lameness score 1). This dog showed no signs of lameness most of the time, however, after hard exercise or when running in circles, a low degree lameness was noticed. One result was rated

Table 1: Clinical, radiographic and follow-up findings of the dogs that were represented for clinical and radiographic re-evaluation (Group 1).

Clinical outcome and radiographic data for Group 1					
Breed	Age at first presentation	Pre-op radio-graphic arthrosis	Post-op radio-graphic arthrosis	Clinical outcome	Time to follow-up
Newfoundland	6 years, 1month	Grade I	Grade I	excellent	14 months
Beauceron	6 years, 11 months	Grade I	Grade II	poor	32 months
Bernese Mountain Dog	4 years, 4 months	Grade II	Grade II	excellent	22 months
Border Collie	4 years, 5 months	Grade I	Grade II	excellent	22 months
Border Collie	4 years, 6 months	Grade I	Grade I	excellent	20 months
Border Collie	3 years, 9 months	Grade II	Grade III	good	31 months
Bernese Mountain Dog	10 months	Grade I	Grade II	excellent	43 months
Bernese Mountain Dog	1 year, 11 months	Grade I	Grade I	excellent	14 months
Bernese Mountain Dog	3 years, 9 months	Grade I	Grade I	excellent	24 months
Rottweiler	3 years, 7 months	Grade I	Grade II	excellent	31 months
Irish Wolf Hound	6 years, 6 months	Grade I	Grade I	excellent	13 months

as 'poor', as the dog suffered from permanent low to moderate lameness. A second arthroscopic examination revealed fibrous tissue originating from the supraglenoidal tubercle running in the inter-tubercular groove. The lameness did not improve after the second arthroscopic transection of the fibrous tissue. Despite the latter case, none of the dogs developed an abnormal gait or an inability to flex the elbow. In Group 2, 92% (13/14) of the results obtained via the questionnaire were rated as 'excellent'; one report was rated as 'good'. No cosmetic deformities were noticed in Group 1 or in Group 2. A total of 10 dogs (11 joints) were evaluated radiographically and revealed no progression of pathology in 6 joints (55%). Five joints (45%) showed a limited progression of pathology. The median progression was 0 (Table 1).

Discussion

The goal of surgical treatment in partial bicipital rupture is to eliminate movement of the tendon in the inflamed tendon sheath. This can be accomplished with either tenodesis or tenotomy. Initially, biceps tenotomy was criticised based on bio-mechanical data and a lack of long-term clinical results [22-24]. The biceps muscle-tendon unit is one of many structures in the canine body to cross two joints. In the elbow, it serves as a flexor and supinator. Whilst its function at the elbow is clear, its role in the shoulder remains controversial. An in vitro study by Sidaway [24] has confirmed that the biceps tendon contributes to the passive shoulder stability, particularly in the neutral and flexed positions. However, scapulo-humeral stability after bicipital tenotomy should be comparable to that after a traditional bicipital tenodesis. If significant instability had been present after tenotomy, we would have expected clinical, and eventually radiographic signs after a longer period of time, which did not occur in this study. It seems clear that the biceps tendon does not have a primary stabilizing function in the shoulder but has multiple secondary roles instead. Therefore, as no primary function can be isolated it is not surprising that there is no single reliable clinical test or single treatment in biceps pathology.

In human medicine, tenodesis was initially advised to re-establish the resting muscle length and thereby maintain the length-tension relationship, prevent muscle atrophy, avoid cramping pain, maintain elbow flexion and supination strength and avoid cosmetic deformity (Popeye sign) [25]. Currently, tenotomy is becoming more popular than tenodesis [26-28]. Mariani et al. [29] compared 30 patients with spontaneous rupture of the long head of the biceps treated non-operatively with 26 patients who underwent early biceps tenodesis. They found only a 13% difference in the biceps' supination strength between the two groups and no difference at all in elbow flexion strength. However, in patients who are concerned about potential cosmetic deformity and associated dysfunction, tenodesis might be advantageous. It is important to note that none of the dogs in this study developed an abnormal gait, a cosmetic deformity or the inability to flex the elbow.

Pre-operative clinical findings in this study are similar to those reported in the literature however in 2 patients (8%) hyperextension of the elbow was possible despite the fact that the biceps tendon was not completely ruptured.

Clinical outcome was excellent in 22 shoulders (88%), with each dog showing a full return of limb function. Symptoms disappeared rapidly in the majority of the dogs at a mean time of 3 weeks. Since most dogs showed immediate pain relief it is likely that tenotomy eliminates the painful traction forces that are exerted on the non-ruptured part of the affected biceps tendon and its attachment to the supraglenoid tubercle. In one case, the dog had a recurrence of symptoms six weeks after surgery and suffered from low to moderate permanent lameness for 24 months. After other joint problems were ruled out, the dog underwent a second arthroscopic examination which revealed the presence of fibrous tissue at the normal location of the bicipital tendon. The authors believed that this was the result of an incomplete tenotomy of the biceps tendon in the initial arthroscopy. During arthroscopic tenotomy, the tendon does not always retract clearly in its groove which can make it difficult to judge whether or not the tendon is completely transected, particularly in chronic cases. However, even after the second tenotomy the owner could still see no improvement 10 months post-operatively. Another explanation could be that the initial diagnosis was incorrect. This stresses the importance of a complete diagnostic work-up that carefully rules out other pathologies. Fibrillation of the MGHL present in 32% (8/25) and a partial rupture of the MGHL present in 4% (1/25), were regarded as secondary findings. Post-operative exercise restriction could have contributed to the recovery of these structures. None were surgically treated and the outcome was rated 'excellent' in all affected dogs, therefore, we recommend caution in interpreting such findings as a primary clinical problem, because, in our opinion, some could be coincidental findings of no clinical significance. Although it was limited, degenerative joint disease was present pre-operatively in all dogs from Group 1. We could not demonstrate a correlation between presence of increase in grade and the clinical outcome, however, all dogs with post-operative grade I (5/11) had excellent clinical outcomes. Dogs showing clinical signs for more than 5 weeks were associated with higher post-operative grades, which suggests that early recognition and treatment could produce better clinical outcomes. The number of radiographic cases is not large enough for statistical analysis.

A major limitation of our study is that tenodesis (open or arthroscopically) was not evaluated as an alternative treatment. Because no comparison was made, tenotomy cannot be considered superior to tenodesis based on the available data, however data from the present study indicate that tenotomy results in good to excellent long-term outcome. Long-term studies designed to evaluate a more complex treatment (tenodesis) have not yet been made. Another limitation is that dogs from Group 2 were evaluated only by a subjective questionnaire, however the results achieved in both groups were consistent, and the overall clinical outcome for both groups was rated 'excellent' in 88% of cases. Force plate analysis, computed tomography and arthroscopy would have contributed important data to this study, but they were beyond the scope of this work for financial reasons and the desire not to tax the goodwill of

the owners. Indeed, owners are not inclined to come for an additional examination if no problems are present. This could have affected our results – even positively – because, for the majority of the dogs, the short-term results (which are not included in this study) were rewarding.

Variables in our study were epidemiologic aspects and the different functions, environments and pre-surgical management. Only one dog from Group 1 was a working dog – nevertheless, outcome was excellent after bilateral arthroscopic tenotomy.

We conclude that arthroscopic tenotomy in the treatment of bicipital partial rupture yields favourable long-term clinical results and a high degree of owner satisfaction. Although it cannot be considered superior to tenodesis, the feasibility of applying this technique and the long-term clinical and radiographic outcomes from our study suggest that this technique can be considered a safe, reliable treatment for partial bicipital rupture.

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REPRINT PAPER (CSASVA)

Diabetes mellitus in dogs and cats – clinical experience with bioactive chromium supplementation in dogs treated with insulin

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INTRODUCTION

This article provides an overview of diabetes in dogs and cats in general and details the importance of chromium action in the therapy of diabetic patients. In the final section, results of chromium supplementation in 17 diabetic dogs are described. The levels of glycaemia of all animals initially treated with insulin only are statistically compared to glycaemic levels after adding bioactive chromium to the therapy. A statistically significant positive effect of chromium supplementation to diabetic dogs treated with insulin is documented. The decrease of glucose level may be explained by elevated insulin activity or as reduction of insulin resistance, mediated by means of chromium supplementation.

Key words: diabetes mellitus, chromium, therapy, dog

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Introduction

Diabetes mellitus is a relatively frequent endocrine disturbance of dogs and cats. The incidence in both species is approximately 1:100 to 1:500 [1]. Typically diabetes affects older dogs between 7-9 years and cats between 9-11 years. The occurrence of juvenile diabetes in dogs and cats before the first year of age is uncommon [1].

Blood glucose measurement should be a routine part of the emergency database, preoperative assessments, and preventive geriatric programmes. Additionally, levels of glycaemia and glycosuria should be one of the basic laboratory parameters measured in the differential diagnosis of polyuria/polydipsia. These screening tests can enable the early diagnosis of diabetes. The need for injectable insulin is the basis for the current classification of diabetes in dogs and cats. In animals, the nomenclature insulin dependent diabetes mellitus (IDDM) and non insulin dependent diabetes mellitus (NIDDM) is preferred to the human subdivision of Type I and Type II diabetes [1]. However, diabetes in dogs and cats may not fall within this preferred classification. Some patients with NIDDM, particularly cats, have varying insulin requirements throughout disease progression [1]. This is due to increasing insulin resistance and varying insulin production in the damaged beta cells of the pancreas [1]. A range of pathological processes in the pancreatic islet cells, either progressive or static, can vary from mild to severe [1]. The severity of the pathological process contributes to the stage of the disease, as it affects the ability of the islets to produce insulin, resulting in a reducing insulin secretion with time and

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dog	cat
Genetic disposition	Pancreatic islet amyloidosis
Pancreatitis	Obesity
Immune mediated insulinitis	Pancreatitis
Obesity	Other endocrinopathies - hyperadrenocorticism - acromegaly - hyperthyreosis
Other endocrinopathies - hyperadrenocorticism - dioestrus-induced increased levels of growth hormone - hypothyreosis	iatrogenic -glucocorticoids - megoestrol acetate
iatrogenic-glucocorticoids	Infection
Infection	Other diseases - renal insufficiency - heart diseases
Other diseases - renal insufficiency - heart disease	Hyperlipidaemia
Hyperlipidaemia	Genetic disposition
Pancreatic islet amyloidosis	Immune mediated insulinitis

Tab.1 Potential aetiologic factors of IDDM (modified from Ettinger)[1]

disease progression. Therapeutic success is determined by the tissue response to insulin, which in turn depends on concurrent inflammatory, infectious, neoplastic, or hormonal disorders, and therefore the need and dosage of insulin [1].

IDDM is characterized by permanent hypoinsulinaemia and the need to provide exogenous insulin to maintain normoglycaemia [2] Aetiology of diabetes is multifactorial, (see Table 1).
However, an increased risk of diabetes is seen in some breeds (Australian terrier, Schnauzer, Bichon Frise, Pomeranian, Fox terrier, Poodle, Yorkshire terrier, Maltese and others) [2].
The most common cause of IDDM in dogs is probably the autoimmune destruction of the pancreatic islet in combination with genetic predispositions and environmental factors [1].

Clinically NIDDM is seen more frequently in cats than in dogs, and it is commonly caused by pancreatic islet amyloidosis. Like insulin, amyloid peptides, or amylin, are secreted from pancreatic beta cells and act predominantly postprandially as neuroendocrine hormones with additional gluco-regulatory effects synergic to insulin. Chronically increased insulin and amylin secretion, which occur in obesity or other insulin resistant states, leads to aggregation and formation of amylin deposits. Amylin is cytotoxic to the pancreas leading to apoptosis of islet cells, and subsequently a reduction in insulin secretion. The stage of this pathologic process determines if diabetes is insulin dependent (in a cat with complete islet destruction) or non insulin dependent (in a cat with a partial islet destruction). If the process of amyloid deposition in cats is progressive, it gradually results in the conversion of NIDDM to IDDM. The presence and range of insulin resistance in cats with partial islet destruction is variable and affects the clinical stage of the disease. As insulin resistance increases so does the need for insulin secretion. With a higher degree of insulin resistance, and a larger loss of functional islets, the probability of hyperglycaemia increases. Persistent hyperglycaemia can consequently suppress the function of the remaining beta cells and cause hypo-insulinaemia thereby increasing levels of hyperglycaemia.

Causal factors of NIDDM in cats are obesity, chronic pancreatitis, acromegaly, hyper-adrenocorticism and long term treatment with glucocorticoids or megoestrol acetate.

In dogs NIDDM usually manifests as a result of concurrent disease antagonising insulin or as a result of medicaments, particularly glucocorticoids [1]. A typical example of hyperglycaemia is in the intact bitch during dioestrus [1].

Diagnosis of diabetes in dogs and cats is based on the presence of hyperglycaemia and glycosuria while fasting [1]. In dogs IDDM is the most common type, so all of these patients should be treated with insulin where an underlying condition antagonising insulin secretion is not suspected [1]. In cats it is important to try to differentiate IDDM from NIDDM, because of the higher probability of NIDDM or transient type diabetes. Measuring serum insulin levels to differentiate IDDM and NIDDM does not appear to be reliable. If serum insulin levels are higher than normal (mean concentration above 12 µU/l), functional beta cells are likely and there is a possibility of NIDDM [1]. However, reliable differentiation of IDDM and NIDDM in cats is only possible retrospectively, by the assessment of the response to insulin after several weeks of treatment. The initial decision to use insulin or oral anti-diabetics is dependent on the clinical symptoms, the presence of ketoacidosis, the health status of the cat, and also the compliance of the pet-owner [1].

As a consequence of a relative or absolute lack of insulin secretion, hyperglycaemia is caused by decreasing the utilisation of glucose, amino acids, and fatty acids in peripheral tissues, and increasing hepatic glycogenolysis and gluconeogenesis. Additionally glucose absorbed from food increases the level of hyperglycaemia. Hyperglycaemia saturates renal tubular function preventing reabsorption of glucose back from glomerular ultrafiltrate, leading to glycosuria. This osmotic diuresis leads to polyuria and compensatory polydipsia to prevent dehydration. The decreased ability of peripheral tissues to utilise absorbed glucose leads to weight loss. The body tries to compensate this "peripheral starving" by increasing appetite. Polyphagia and the feeling of hunger occur despite hyperglycaemia by blocking the entrance of sufficient amounts of glucose to cells of the hypothalamic centre [1]. The situation of uncontrolled hyperglycaemia leads to diabetic ketoacidosis. This is caused by the oxidation of non esterified or free fatty acids in the liver, and their use as a source of energy for tissues with a lack of glucose. These free fatty acids are mobilized from triglycerides from fat deposits, and also from the adjustment of the lipid metabolism from synthesis to oxygenation and ketogenesis. Insulin is a powerful inhibitor of lipolysis and oxidation of free fatty acids.

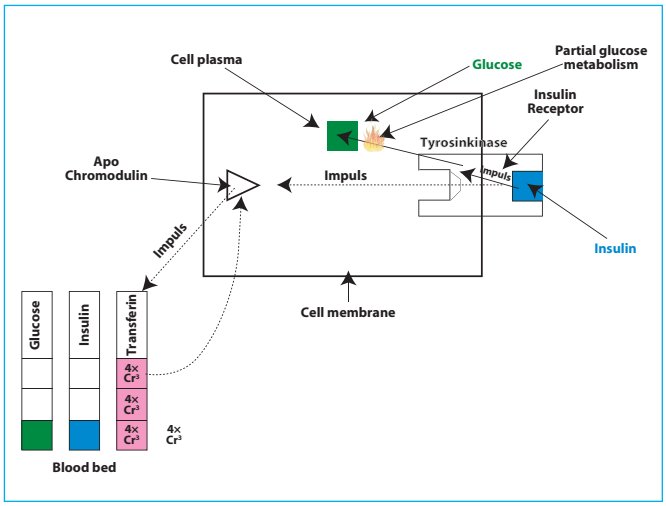

Fig.1 Apo-chromodulin obtains 4 x Cr^{3+} from trasferin. Apo-chromodulin transfers to active chromodulin.

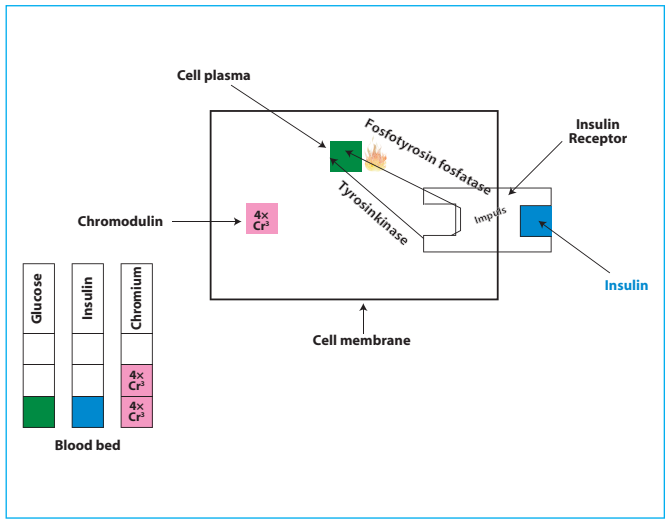

Fig. 2 Chromodulin binds to the inner part of the insulin receptor. Chromodulin fully activates the insulin receptor. The effect of tyrosinkinase increases 18x and together with fosfotyrosin-fosfatase the adequate glucose metabolism is reached.

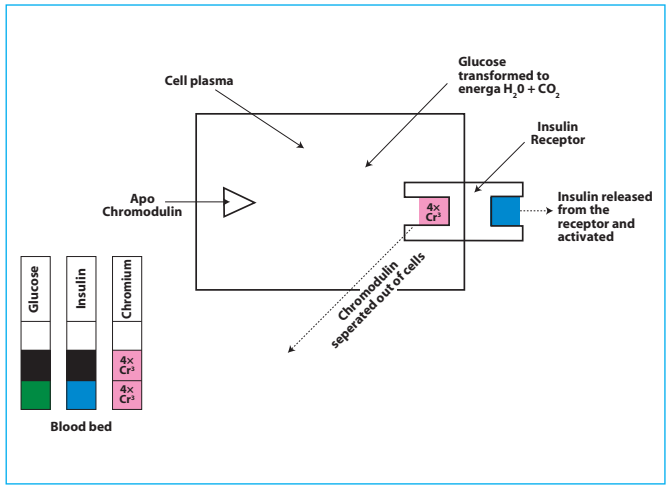

Fig. 3 After finishing the glucose metabolism, the inactivated insulin is released from the receptor bond. Similarly chromodulin bound with 4 atoms of Cr^3 is excreted to urine. The new apochromodulin appears in the cell.

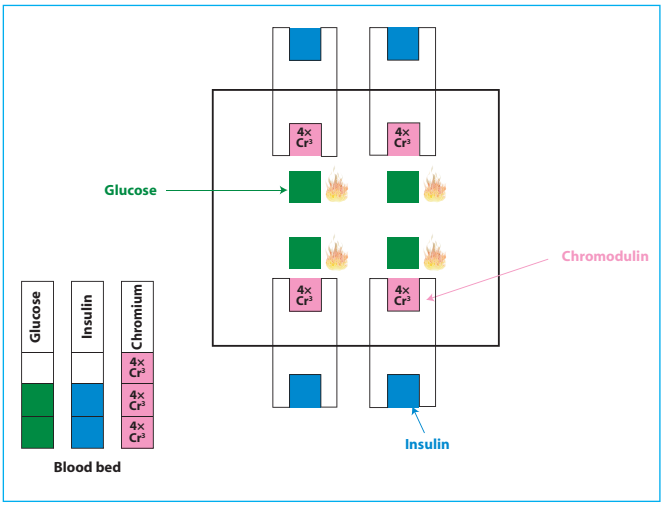

Fig. 4 The full saturation with chromium.

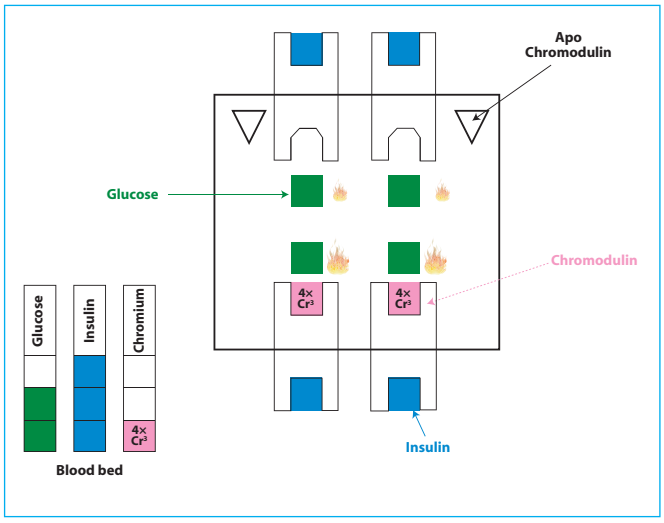

Fig. 5 Insufficient saturation with chromium.

When insulin is deficient, lipolysis increases the availability of free fatty acids for the liver, predisposing it to ketogenesis. Insulin reduction contributes to the increased loss of electrolytes and water from the kidneys, resulting in a decrease in the circulating blood volume. Subsequently hypoperfusion and pre-renal azotaemia develop. Increasing levels of ketones leads to progressive exhaustion of buffer mechanisms and metabolic acidosis. Vomiting and diarrhoea further exacerbate the water and electrolyte loss, increasing the acidosis and dehydration. The blood volume continues to decrease leading to further concentration of glucose and ketones. Subsequently, blood osmolality increases and water moves to the extracellular space leading to cellular dehydration and eventually coma [1].

Mechanism of chromium action in the organism and its relationship to diabetes

Chromium is an essential element involved in saccharide and lipid metabolism. Chromium is an ultra trace element, making its serum level practically impossible to analyse exactly. In

humans, metabolic signs of the lack of chromium are fasting hyperglycaemia and hyper-insulinaemia, disturbed glucose tolerance, decreased number of activated insulin receptors, and the increased concentration of cholesterol and triglycerides. In healthy people chromium is excreted by the kidneys and about 85-95% is reabsorbed back through the tubules. In human patients with Type II diabetes excessive loss of chromium through the urine is seen, the cause of which has only recently been discovered. Increased loss is associated with foods rich in saccharides, which can increase insulin resistance even during insulin therapy [7]. Only a small per cent of chromium is absorbed from food. Absorption is influenced by the chemical form of chromium [2].

Current model for the effect of chromium

After the trivalent chromium is absorbed, it is transported to cells bound to the plasma protein transferin. Insulin initiates chromium transport into cells where it binds to an oligopeptide apochromodulin, which together with 4 molecules of trivalent chromium makes the active chromodulin (this low molecular oligopeptide was isolated from the canine liver in 1983). After binding to insulin receptors, which are activated by the bond of insulin, tyrosinkinase (part of the intracellular side of the insulin receptor) activity increases and glucose metabolism is activated [2]. As a result of the reduction of blood insulin concentration, chromodulin is released from the cell and excreted via kidney. As chromium binds to the chromodulin, it cannot be recirculated. This may be one explanation, why foods rich in calories and carbohydrates contribute to chromium depletion. (see figures 1-5) [3].

Materials and Methods

Seventeen diabetic dogs were included in the study. Blood glucose was measured regularly for a prolonged period. 9 dogs were suspected to suffer from IDDM and 8 bitches were suspected to suffer from NIDDM. Blood glucose was monitored previously for weeks to months from the beginning of the therapy and was measured directly after blood sampling in the consulting room of the clinic by a glucometer (One touch ultra). Cases of hyperglycaemia were initially treated with medium-long acting biosynthetic human insulin (Insulatard HM 100 IU/ml) injected subcutaneously (1-1, 5 IU/kg). Blood glucose levels were always measured while fasting in the period of maximal effect of insulin, 6-8 hours after the morning injection by the owner. When blood glucose fell below 15 mmol/l, and at least two sequential fixed levels of blood glucose on an unchanged dose of insulin were achieved, bioactive chromium (Bioaktivní Chrom Dia, 100 µg Pharma Nord, Vejle, Denmark) in the form of cellular bound chromium yeast (ChromoPrecise® Yeast Pharma Nord Vejle, Denmark) was added to the diet (100 µg per day).

In all bitches, after stabilizing glycaemia below15 mmol/l with the insulin monotherapy, ovariohysterectomy was performed .In this group of diabetic animals bioactive chromium was initiated after this procedure.

For the statistical assessment of the efficacy of bioactive chromium, dogs remained on the same dose of insulin as before the supplementation, and two sequential measurements of blood glucose during the first and second week after initiating the supplementation were used during regular checkups of the animals treated with the combination of insulin and bioactive chromium.

	Initial glycemia	Glycemia within insulin therapy		Glycemia within insulin + chromium therapy	
Number of column ..... patient	0	1	2	3	4
1	15.5	9.9	11.3	3.3	6.7
2	9.4	12.9	14.2	10.1	12.5
3	11.8	14.1	13.4	9.2	4.5
4	26.4	18.4	18.0	3.7	10.4
5	22.4	10.9	13.2	10.2	8.6
6	25.4	14.8	11,5	7.6	10.8
7	21.6	14.4	11.0	9.8	5.0
8	17.8	15.6	17.8	6.4	6.4
9	24.8	14.1	7.1	7.2	3.5
10	16.6	17.5	9.3	11.2	10.8
11	28.4	13.9	9.6	11.6	5.4
12	16.3	13.1	11.2	4.1	3.6
13	24.1	4.7	9.1	4.6	4.3
14	24.3	14.4	11.2	6.6	11.2
15	28.5	28.6	20.6	11.7	9.0
16	over 40	15.5	6.4	2.1	5.2
17	over 40	25.4	18.0	5.1	9.7

Table 2: Tested levels of glycaemia of the dogs treated with insulin and consequently with insulin and bioactive chromium supplementation.

Results

Table 2 shows successive measurements of blood glucose. The first 9 rows represent the patients (male dogs) with suspected IDDM. The numbers from 10-17 the patients (bitches) with suspected NIDDM. Column 0 represents the original glucose value without therapy, column 1 and 2 represent the two levels of glycaemia during monotherapy with insulin and column 3 and 4 represent the two subsequent levels of glycaemia during the unchanged therapy with insulin supplemented with bioactive chromium.

The columns with insulin monotherapy (column 1 and 2) were statistically analysed without the initial hyperglycaemia (column 0). Analysis was performed by double selective Wilcoxon´s test (Mann-Whitney U-test). Values in columns 1 versus 3 and columns 2 versus 4 were compared. The hypothesis tested was that column 1 and 3 came from the same distribution with the same medians. The alternative hypothesis tested was that columns 1 and 3 did not come from the same distribution nor

did they have the same medians. Results of the test negate the hypothesis on the level of relevancy p = 2.1992e-006 (or 0.0000021992). This means that we can conclude that the medians differ very significantly. The presumption (p-level), that this statement is not valid, is smaller than or equal to 2.1992e-006 (approx. 2 millionth).
The comparison of column 2 and 4 is based on the hypothesis, that both come from the same distribution with the same medians. The alternative hypothesis is that columns 2 and 4 do not come from the same distribution nor do they have the same medians. The test is again performed by double selective Wilcoxon´s test (Mann-Whitney U-test).
The results of the test negate the hypothesis on the level of relevancy p = 7.6788e-004 (0.00076788). In practise this means that we can conclude that the medians differ very significantly. The presumption (p-level), that this statement is not valid, is smaller than or equal to 7.6788e-004 (approx. 8 ten-thousandth).

Discussion

Our clinic has a long-term positive experience of treating diabetic dogs and cats with human insulin. We prefer this choice due to a subjectively good therapeutic effect (over a prolonged period) and relatively good financial sense for owners. In patients we currently recommend the initial dose of insulin at 1 IU/kg of body weight once daily, however, in some patients a divided dose is more effective. When the reduction in blood glucose is not sufficient we increase the dose to a maximum of 2 IU/kg of body weight. In tested patients a single daily dose was given. In entire bitches with suspected NIDDM the response to exogenous insulin is usually insufficient due to the hormonally mediated peripheral tissue resistance. For this reason we perform ovariohysterectomy in these patients as soon as possible. This procedure should be performed once the blood glucose is stabilized, or after correction of a metabolic ketoacidosis, if insulin therapy fails to produce an adequate decrease in glucose levels. In patients with higher levels of glucose for a longer time despite insulin therapy, dietary chromium supplementation was recommended.

In humans, chromium supplementation increases glucose tolerance and some parameters of lipid metabolism. The lack of chromium can contribute to insulin resistance and hyperlipidemia. In rats fed a chromium-free diet, all symptoms of diabetes, paradoxically resistant to insulin, were manifested. After adding the trivalent chromium to their food, the glucose tolerance was restored and all symptoms vanished [2). A similar development of symptoms was observed in human patients on intravenous nutrition without chromium. After addition of chromium to the infusion all abnormalities resolved [4]. Several long-term scientific studies in human patients with Type II diabetes mellitus have confirmed that chromium supplementation led to a statistically significant decrease of hyperglycaemia and hyper-insulinaemia [2].

Supplementation of bioactive chromium is recommended to diabetic patients with insufficient response to insulin therapy, or when repeatedly measured blood glucose levels tend to vary markedly. In our animals an organic complex of chromium bound to bakery yeast (Bioaktivní ChromDia 100 µg, Pharma Nord, Vejle, Denmark) in the form of chromium bound yeast (Chromo Precise® Yeast Pharma Nord Vejle, Denmark) is supplemented, as this form can be easily absorbed [2].

Large variations in absorption of differing compounds of chromium were described, even among species [2].
In healthy people the effects of chromium supplementation have not been confirmed, but in individuals with a chromium deficit, supplementation has a demonstrable effect. In patients with insulin resistant Type II diabetes, an increased loss of chromium through the kidneys is suspected advocating chromium supplementation. Insulin resistance often precedes the manifestation of clinical symptoms of diabetes, therefore early chromium supplementation can prolong the period before the symptoms of diabetes are displayed. No side effects of supplementation have been described [2].
The classic subdivision of human diabetes into 2 basic types (Type I-insulin dependent and Type II-insulin resistant) is not completely without exceptions. In Type II diabetes the insulin secretion persists, and in most cases hypersecretion occurs. In this phase chromium supplementation increases the effect of this secretion and the use of insulin is not usually required. Exogenous insulin is required in advanced stages of Type II diabetes, when the endogenous insulin secretion decreases, and probably the low chromium saturation persists. According to the so far unpublished information, in these human patients chromium supplementation combined with insulin therapy enables the reduction of the dose of insulin [3]. On the basis of our long-term observation, we suppose the same principle applies in canine diabeties with NIDDM.

The results of our study have shown that addition of chromium to the diet has a positive effect in decreasing blood glucose levels of diabetic dogs already on treatment with insulin.
In the experimental group 20 animals were monitored. From this group 9 were male-dogs with suspected IDDM, 8 were bitches with suspected NIDDM, and 3 were cats. The 3 cats have not been included in the statistics. The reasons for this exclusion from the statistical assessment was that only a small number of feline patients were treated with insulin, stress-induced hyperglycaemia in cats, and thirdly we supplemented cats with a lower dose of chromium relative to dogs (30 µg to cats versus 100 µg to dogs). Despite these facts a positive effect of supplemented chromium was seen during long-term monitoring. Statistically the levels of glycaemia were analysed without differentiation of patients to IDDM and NIDDM type. To be able to analyse both groups separately the number of patients in each group has to be increased.

Conclusion

Supplementing chromium yeast to the diet in diabetic dogs already treated with insulin produced a statistically significant decrease in blood glucose levels. Large variations in the absorption of differing compounds of chromium were described, even among species. In our patients an organic complex of cellular bound chromium yeast (ChromoPrecise® Yeast Pharmanord,

Vejle, Denmark) was used, as this form of chromium can be easily absorbed. From this study we can conclude, that in addition to the decrease in insulin production, hyperglycaemia in dogs was also caused by increased tissue resistance to insulin in patients with IDDM and NIDDM. We suppose that chromium supplementation led to a natural increase of the tissue glucose tolerance, which is a more physiological and safer way to decrease hyperglycaemia in treated diabetic dogs than just increasing the dosage of insulin.

Acknowledgements

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ORIGINAL WORK (UK)

Spinal haemorrhage associated with factor VII deficiency in a young Beagle

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SUMMARY

A 6-month-old entire female Beagle was presented for investigation of acute onset paraparesis and hindlimb ataxia. After neurological examination a multifocal neurological localisation was suspected. Magnetic resonance imaging scans of the dog's cervicothoracic region revealed an intradural/extramedullary spinal cord lesion between the T8 and T9 vertebral segments; in addition, another lesion adjacent to the dorsal aspect of the first cervical vertebra which infiltrated mainly the epaxial muscles was visualised. A mild prolongation of prothrombin time was detected. A genetic polymerase chain reaction assay to confirm the presence of factor VII deficiency was carried out and indicated a homozygous condition for the defective gene. Factor VII deficiency as well as other coagulopathies should be considered as a differential in dogs with neurological deficits.

Keywords: Beagle, factor VII deficiency, ataxia, paraparesis, magnetic resonance imaging

Introduction

Factor VII (FVII) is a vitamin K-dependent glycoprotein synthesised in the liver and secreted into the circulation as a zymogen that, once activated, plays a vital role in the initiation of coagulation [1, 2]. FVII deficiency in humans is a rare autosomal recessive coagulopathy [3]. Hereditary FVII deficiency has been previously reported in research colonies of Beagle dogs as well as in the companion animal population [4, 5, 6, 7, 8] and recently it has also been described in Alaskan Klee Kai dogs [9]. FVII deficiency is an autosomal recessive trait in the Beagle and affected dogs are homozygous for this mutation [10]. There are reports of mild to severe bleeding in affected dogs [5, 7, 8, 9, 11] but to the best of the authors' knowledge there is no data available regarding FVII deficiency associated with a neurological involvement. Suspected spinal and muscle haemorrhage associated with a coagulopathy caused by a FVII deficiency in a Beagle is the subject of this case report.

Case history

A 6-month-old entire female Beagle was referred for investigation of acute onset paraparesis and bilateral hindlimb ataxia. On neurological examination the dog appeared subdued; cranial nerve function was normal. An ambulatory paraparesis and spinal ataxia were noted. Hopping deficits were observed in the hindlimbs and proprioceptive positioning was absent in both hindlimbs. Deep pain perception was preserved in all four limbs. Moderate pain could be elicited during palpation of the thoracolumbar paraspinal muscles and during lateral movements of the dog's neck towards both the left and the right side. The panniculus reflex was bilaterally absent caudally to the cranial thoracic region. Neurolocalisation indicated a lesion of the cervicothoracic region. Thoracic and abdominal radiographs were normal. Magnetic resonance imaging (MRI) scans (Vet-MR Grande, Esaote S.p.A., Genoa, Italy) of the dog's thoracic and neck regions were obtained in three planes of orientation before and after the intravenous administration of

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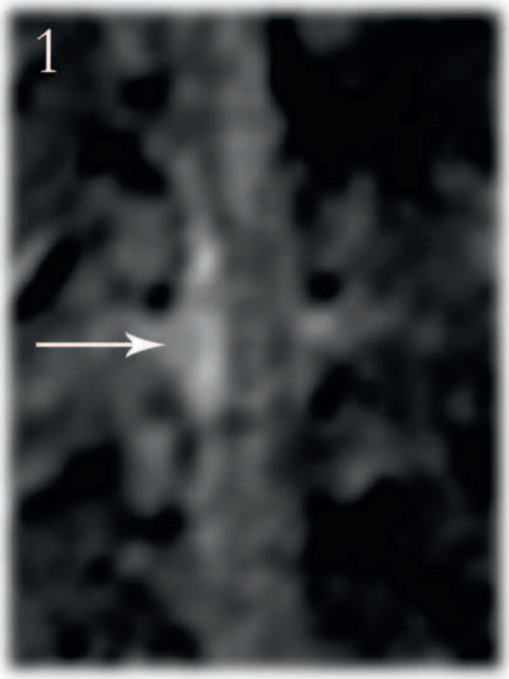


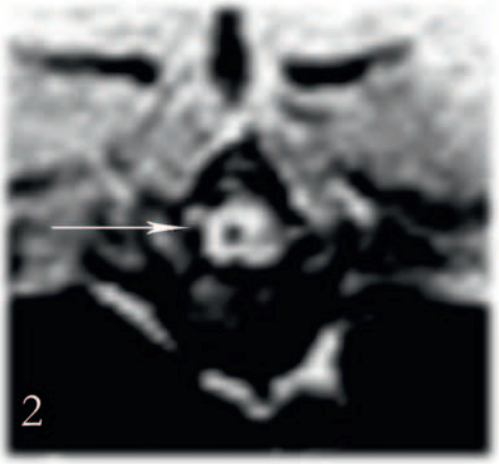
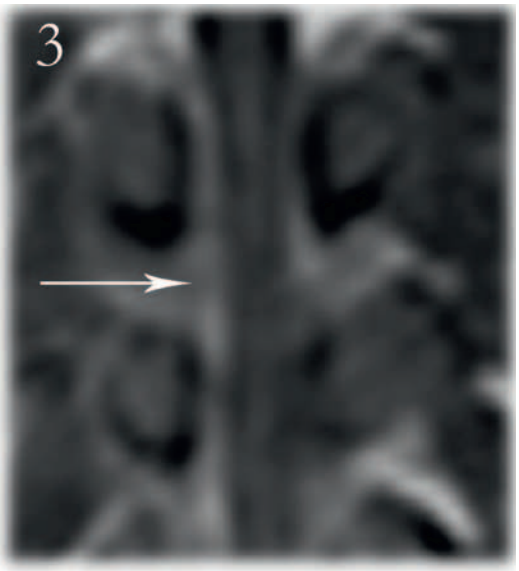
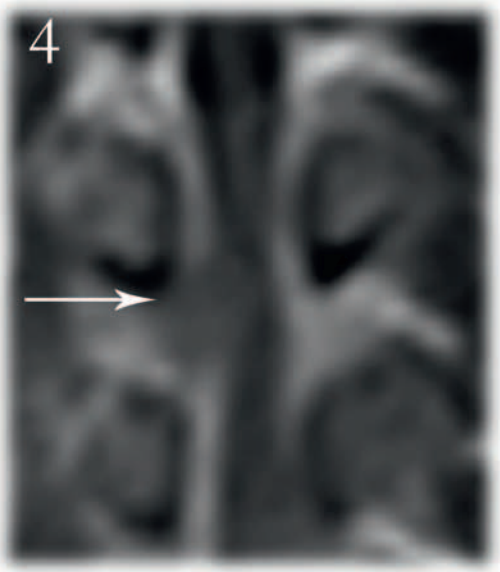


Fig (1) Dorsal STIR and Fig (2) transverse GE images of the spinal cord at T8/T9. There is an intradural/extramedullary irregular lesion invading the right side of the spinal cord parenchyma (white arrows). On STIR image the lesion is homogeneously hyperintense whereas on GE image it contains a hypointense central focus surrounded by a hyperintense rim.

0.1 mmol/kg gadolinium (Magnevist®, Schering, Germany). A C-shaped solenoid coil was used. Slice thickness was 3.5 mm and slice interspace gap was 0.3 mm. On T2-weighted (T2W) (repetition time (TR): 2000 ms, echo time (TE): 80 ms) and short-tau inversion recovery (STIR) (TR: 1500 ms, TE: 15 ms, time to inversion: 120 ms) sequences there was an intradural/extramedullary hyperintense region between the T8 and T9 vertebral segments on the right side (Fig. 1). The lesion appeared hypointense on gradient echo (GE) (TR: 1200 ms, TE: 22 ms, flip angle: 45) sequence (Fig. 2) and slightly hyperintense on pre-contrast T1-weighted (T1W) (TR: 700 ms, TE: 18 ms) sequence. After the intravenous injection of the contrast medium a slight enhancement was visualised (Fig. 3, Fig. 4). These findings were considered compatible with a recent intradural/extramedullary spinal cord haemorrhage. In addition, another lesion was visualised involving and infiltrating the epaxial muscles dorsally to the atlas. This lesion was hyperintense on STIR, T1W and T2W pre-contrast images (Fig. 5) and was interpreted as a recent muscle haemorrhage or a myositis. Since the neck lesion was close to the foramen magnum and a coagulation disorder was suspected, cerebrospinal fluid (CSF) sampling was considered inadvisable. The dog was hospitalised and as the findings of the clinical examination and imaging were considered consistent with either haemorrhage or inflammation, the dog was given a course of oral prednisolone (Prednidale®, Dechra, Shrewsbury, United Kingdom) at 1 mg/kg once a day. Serology for *Toxoplasma Gondii* and *Neospora Caninum* was undertaken by immunofluorescent antibody tests and gave negative results. Faecal analysis by Baermann flotation was negative for lungworm larvae. Routine haematology (Vet ABC analyser, Abaxis, USA), serum biochemistry (IL 650 biochemistry analyser, Instrumentation Laboratories, United Kingdom), and serum electrolytes (IL 650 biochemistry analyser, Instrumentation Laboratories, United Kingdom) were analysed and coagulation tests were undertaken. The red cells appeared normocytic and normochromic with no evidence of increased polychromasia or anisocytosis and platelet morphology and numbers appeared normal. A moderate prolongation of prothrombin time (PT) was detected (28.5 seconds; reference 5 to 12 seconds) using a dried recombinant human tissue factor (Dade Innovin, Siemens, United Kingdom). Partial thromboplastin time (PTT) (Dade





Fig(3) Dorsal pre-contrast T1W and Fig (4) dorsal post-contrast T1W images of the thoracolumbar vertebral segments. The lesion appears mildly hyperintense on T1W pre-contrast image and is slightly enhancing.

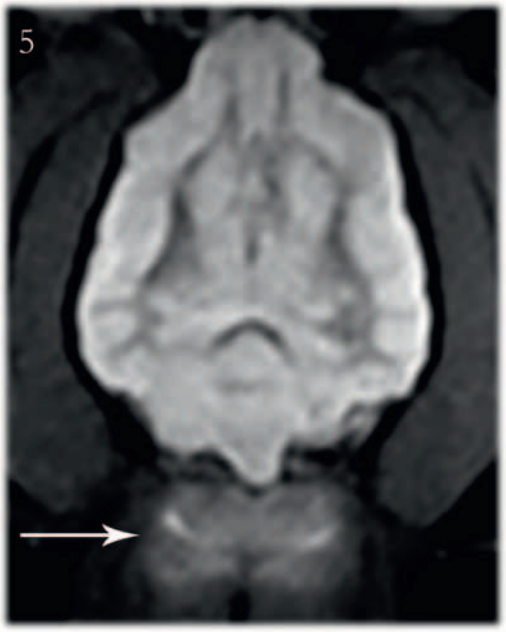


Fig (5) Dorsal STIR image of the brain and cervical epaxial muscles. A diffuse ill-defined hyperintensity can be noted involving and infiltrating the epaxial muscles at the dorsal aspect of the atlas.

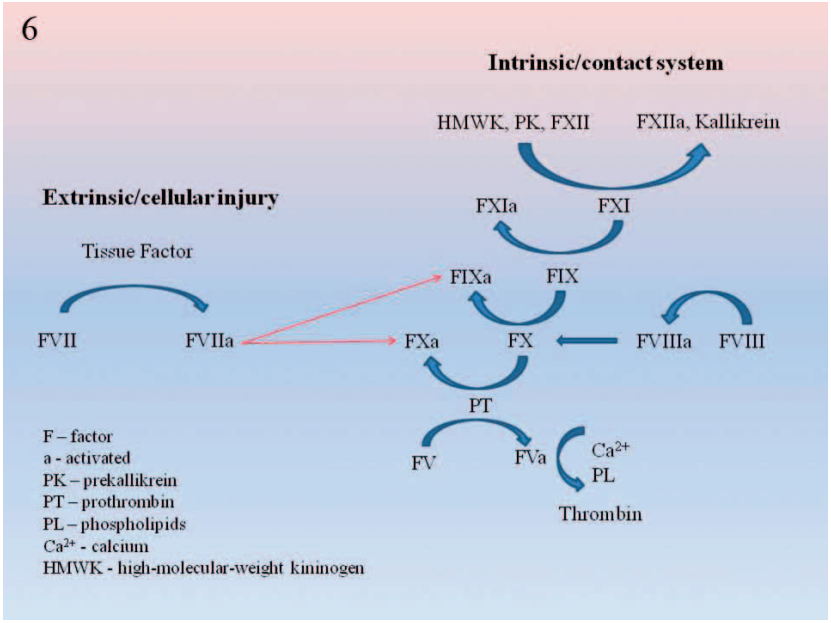


Fig (6) The extrinsic or cellular injury pathway is mediated by the binding of the FVIIa to TF. The FVIIa-TF complex in turn activates both FX and FIX. In the intrinsic or contact system, coagulation is initiated through HMWK, PK, and FXII activation, which in turn activates FXI, which then catalyses the conversion of FIX to FIXa. FVIIIa functions as a cofactor and significantly accelerates activation of FX to FXa by FIXa. Once activated, FXa participates in the prothrombinase complex (FXa-FVa), which, in the presence of Ca2+ and PL, converts PT to thrombin.

Action FS Activated PTT Reagent, Siemens, United Kingdom) was within normal limits. Both the PT and PTT assays were determined manually in duplicate with the reported results being the mean of the two measured clotting times. The extended PT with normal PTT was considered likely to reflect a defect in the extrinsic coagulation pathway. Given the signalment further testing for the inherited coagulopathy associated with FVII deficiency previously reported in this breed was undertaken. A genetic polymerase chain reaction (PCR) assay similar to the one previously validated in this breed [10] (primers and probes upon request) to confirm the presence of this condition was carried out (Laboklin GMBH & Co.KG, Germany) and indicated a homozygous condition for the defective gene. During the next four days the dog's neurological status improved dramatically and the steroid treatment was slowly tapered down. Three months later the dog was presented for neurological re-evaluation; the owners reported that the dog was improving and that her quality of life was now good. On neurological examination she appeared bright and alert with normal gait, spinal and cranial nerve reflexes and no hopping or proprioceptive deficits. No pain could be elicited during manipulation of the neck and palpation of the paraspinal muscles.

Discussion

FVII is a vitamin K-dependent serine protease coagulation factor. It is synthesised in the liver and secreted into the circulation as a single-chain zymogen that, following vascular injury, is converted to the activated form. This, in combination with the membrane protein tissue factor, cleaves factors IX and X (FX) to their activated forms. Once activated, FX participates in the prothrombinase complex consisting of FX and the activated factor V. This complex, in the presence of calcium and phospholipids, catalyses the conversion of prothrombin to thrombin [1, 2] (fig. 6).

FVII deficiency in humans is a rare autosomal recessive coagulopathy, with an estimated frequency of 1:500,000 [3]. Naturally occurring hereditary FVII deficiency has been previously reported in Beagle and in other breeds [4, 5, 7, 8, 9, 11]. FVII deficiency is an autosomal recessive trait in the Beagle and affected dogs are homozygous for this mutation. The molecular basis of hereditary FVII deficiency in the Beagle breed is a G to A missense mutation in exon 5, resulting in substitution of glycine 96 by glutamic acid in the epidermal growth factor-like 2 domain [10]. There are reports of mild to severe bleeding in dogs with FVII deficiency, although in most research Beagle colonies FVII deficiency has been noted incidentally when routine coagulation screens performed prior to experimental studies revealed prolonged PT [4, 7]. Pre- and postpartum uterine haemorrhage [7, 8], excessive bleeding after routine castration [5] and spontaneous severe bruising and haematomas [9, 11] have been reported in dogs affected by FVII deficiency. In the case under study the initial neurological signs were compatible with a disease process of vascular origin. This disorder is characterised clinically by an acute onset of non-progressive and often focal signs. In this particular case the regression observed after a short period of time may be attributable to diminution of the mass effect secondary to haemorrhage and/or oedema resolution [12]. To the best of the authors' knowledge this is the first report of FVII deficiency associated with neurological signs.

The pattern of the spinal cord lesion visualised on MRI in the present case were consistent with recent haemorrhage. Acute neural haemorrhages commonly appear as hyperintense areas on T2W and STIR images and are characterised by isointensity or subtle hyperintensity on T1W images [13, 14, 15, 16, 17]. GE sequence is highly sensitive for detection of blood products; haemorrhages tend to demonstrate low signal intensity regardless of the time from the onset vascular accident, the source of its location or the magnetic field strength [18]. However, hypointensity on GE sequences is not a specific feature of haemorrhage and may also be seen with mineralisation, gas, iron deposits or fibrous tissue [19]. In the present case, after the intravenous administration of gadolinium a slight contrast enhancement was visualised and this has been reported to be caused by the leakage of contrast medium through the damaged blood brain barrier [20]. The lesion involving and infiltrating the epaxial muscles dorsally to the atlas was hyperintense on T2W, STIR and T1W pre-contrast images. These MRI features were thought to represent recent muscle haemorrhage [21] or myositis [22]. The characteristic pattern of abnormalities on routine coagulation tests, however, alerted the authors to the possibility of a coagulopathy involving the extrinsic pathway. This was confirmed to reflect an inherited breed associated abnormality on genetic testing.

Most dogs with vascular accidents affecting the CNS recover with time, as occurred in this case. Management of bleeding in dogs because of a FVII deficiency may be achieved by local control (e.g. compression, cautery) and/or administration of fresh-frozen plasma or plasma cryosupernatants. The latter have been successfully used to control moderate to severe bleeding [9]. Prevention or treatment of bleeding episodes in human patients with FVII deficiency now is frequently achieved by administration of recombinant human activated FVII (rhFVIIa) [23]. Studies are needed to determine whether rhFVIIa can be used safely and cost effectively to supplement or replace plasma components for controlling clinical bleeding in FVII-deficient dogs.

In conclusion, inherited FVII deficiency as well as other bleeding disorders should be considered as a differential in dogs with neurological deficits and MRI features suggestive of underlying vascular disease.

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Telemedicine: a time management and learning tool for vets and service clinics and what it can offer to pet owners

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SUMMARY

Telemedicine provides veterinarians with a means to efficiently acquire specialist support for the management of complex clinical cases and can be offered to pet owners by the clinic as an additional service. Online consultation is preferable when transmitting large amounts of data or high resolution images. It allows a complete presentation of patient history and clinical findings. Queries by veterinarians are facilitated by online questionnaires that guide veterinarians regarding key clinical information. This approach saves both veterinarians and specialists time by minimising exchanges needed to obtain a medical background on the patient. Telemedicine reports can be complemented by e-mail or phone exchanges. In using telemedicine, the main considerations are image format and quality, report quality by the provider and access to a multidisciplinary specialist group. Telemedicine can be implemented as a chargeable service to the pet owner by offering it as an integral part of the clinic's services. The benefits of telemedicine for the veterinarian, clinic and owner include efficiency in the management of more complex clinical cases, a means of continuing education for the veterinarian, and an economic benefit from continued in-house case management due to diagnostic tests, treatments and extended contact with the client.

Keywords: telemedicine, referral, practice management, specialists

Introduction

The economic crisis has yielded a buzz of exchanges in our society on how to do more with less, how to cutback and explore new ideas to improve on the old way of doing things. As this affects all walks of life, veterinarians have not been exempt from its impact.

Time management is perhaps one of the toughest challenges in any business. When confronted with a challenging clinical case, we are often limited by the time required to consult the literature or to track down a specialist by phone in order to narrow down a diagnosis or orient treatment. Telemedicine is beneficial to practices that seek to enhance their time management and constitutes an additional service that can be offered to pet owners. In this article, the focus will be on telemedicine as the consultation between the referring veterinarian attending a patient and the remote specialist, rather than on the broader definition, which includes remote consultation between pet owner and veterinarian and is subject to very different legal and ethical considerations [1].

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Telemedicine as a case and time management tool for the veterinarian

Remote consultation of a case with a veterinary specialist has been around since the dawn of medicine. However, most of the scant literature on veterinary telemedicine has been published in the last decade [2]. Telemedicine has traditionally been based at academic institutions and, more recently, is now being offered by referral centres or telemedicine providers exclusively dedicated to this activity. In past decades consultations have taken the form of telephone or e-mail requests. Advances in telecommunication technology has allowed a new approach, that of online consultation. Online queries allow the veterinarian to make consultations more efficiently, communicating greater detail regarding a patient, and allowing images of large file size to be joined to a query or sent directly from a digital imaging system to the remote server used by the specialist [3]. Online telemedicine provides veterinarians with a written report usually within a short time, with tailored advice for diagnosis, therapeutic management of a case, or imaging interpretation regarding a patient. A study comparing personal vs remote specialist consultation when managing aggressive behaviour in dogs demonstrated that both methods were equally effective in assisting case management [4]. The benefit of a written when compared with a verbal report is that it can be shared with the owner and filed electronically or as a paper copy with the patient records. All information that has gone into the consultation such as the request, report and any files or images submitted are also stored as a copy by the telemedicine provider. This is important as digital image archiving by clinics that do not adopt a complete imaging solution when they make the switch to digital, is often an unsatisfactory and unaddressed problem. With online telemedicine, high resolution images eg. X-rays, CT, MRI, (Fig. 1) and other patient data, including video files, eg. ultrasound, can be sent with relative ease and speed, compared to a few years ago [5] (Fig. 2). Although radiology has been the most popular discipline for remote consultations, telemedicine extends to most areas of medicine for example, surgical consultations or pathology and comment on microscopic images [6,7].

Figure 1. Advances in telecommunications technology and digital imaging, such as this CT of a dog's head, enables electronic transmission of large file sizes, facilitating telemedicine consultations between veterinarians and specialists.

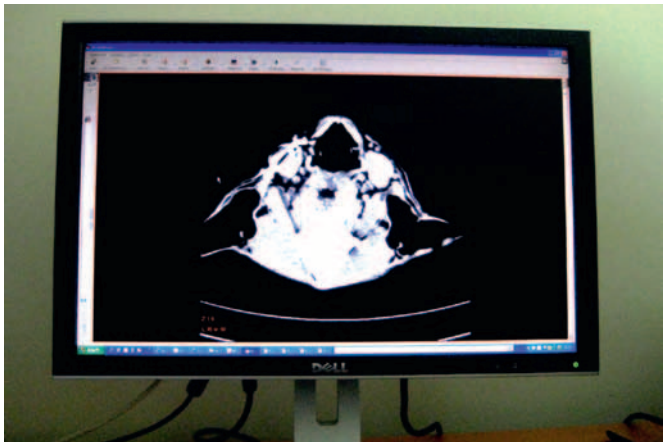

Figure 2. Telemedicine can be applied to most medical disciplines and is especially useful for imaging. Here, a cardiologist is interpreting images from echocardiography in a cat. High image quality is paramount in getting the most out of a telemedicine consultation.

Telemedicine as a service to the pet owner

Although online consultations save time and money, a few points should be considered to make the use of telemedicine more effective. Telemedicine is still a relatively new concept to sell to the pet owner as a service and consequently it is used in different ways by different clinics. It can be offered as an option in the form of a premium service that owners can choose if they wish for their animal to continue to receive treatment at their primary clinic, enabling a presumptive diagnosis to be confirmed or information interpreted. On the other hand, it may form part of the practice's management system. For example, all or most imaging examinations may be sent electronically to a board certified radiologist for a report. Some veterinarians hesitate to divulge to clients that they are seeking a second opinion, because they fear it may be viewed by pet owners as a lack of skill or knowledge. However, integrating telemedicine into the array of a practice's services can help address how it is viewed by the client.

The need for structured consultation requests

If a case exceeds the veterinarian's knowledge and skill, it has always been considered ethical to consult a more experienced colleague. Frequently it is what the veterinarian does not see on the radiograph –errors of omission – that can hinder diagnosis. Informal consultations are free of charge and can provide varied opinions (eg. via a forum). They are good for situations when limited information is exchanged: a sampling of images of small file size; when confirming a doubt or seeking alternative treatment options. This does not readily allow a report to be stored in the patient's record thus making the information solely verbal in nature. Disadvantages of e-mail or telephone requests

is the difficulty one often has in reaching a colleague, and a variable turnaround for a response. More importantly, these consultations risk leaving out information, in the initial query and consequently, in the specialist's response.

In some disciplines (eg. internal medicine) consultations are usually more complex than for radiology. Although e-mails or phone calls are useful for follow-up in case discussions, they are not the best modality for an initial query since the submitted patient information may be too incomplete to provide a tailored response. Frequently, the specialist will need to request further information in addition to an initial e-mail or phone query, thus delaying the final recommendations. More detailed information and varied types of files (X-ray, laboratory data) can be attached to an online request along with a detailed history of clinical signs, previous treatments and case evolution. Some telemedicine services address the need to submit a complete case history by providing a step-by-step questionnaire (Fig. 3) that is a memory aide and guides the veterinarian as to what information to include and for the specialist to provide a tailored reply. For these reasons, an online telemedicine consultation provides the most accurate means of transmission of patient information to a specialist and is the most cost- and time effective approach. Also, an online telemedicine request is generally quicker to complete than an email or phone call.

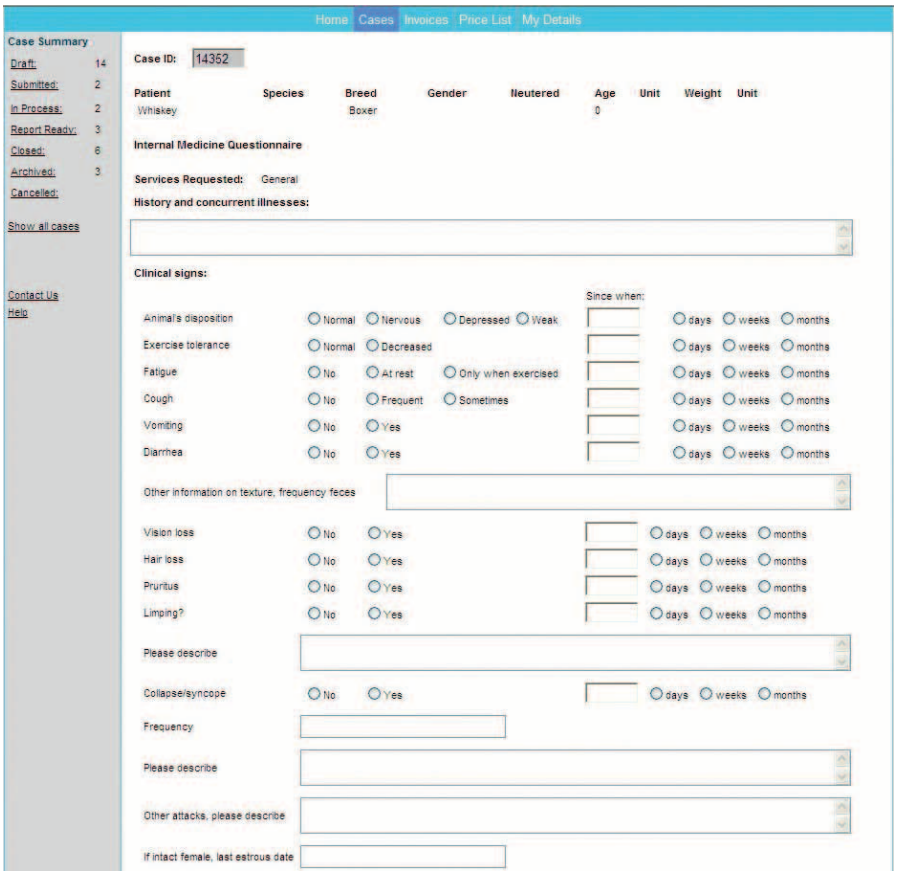

Figure 3. For online telemedicine consultations, an internal medicine questionnaire (partially illustrated) serves as a memory aide for the requesting veterinarian to provide a complete medical history. This increases the speed and completeness of the specialist's response.

With a chargeable telemedicine service, a written report is provided that can be shared with the owner and in part justifies a fee for the service. It is recommended that the telemedicine service be explained beforehand to clients as an integral part of the clinic's services and their consent be obtained. In this way, the owner becomes part of the decision-making process and telemedicine is part of the working ethos of the clinic, as a valuable resource but also to educate clients and veterinarians [8]. The veterinarian can be viewed as working in partnership with specialist colleagues. Alternatively in clinics which already employ specialists, access to a remote team expands on their existing multidisciplinary team. Instead of trying to locate a specialist by phone or via a lengthy email, veterinarians can focus their time on attending cases in the practice. A veterinary assistant can partially fill in the patient data in the telemedicine request forms, further saving time. In this way, telemedicine can be implemented either as a premium service option or used routinely (eg. radiology). An example of the latter is that pet owners may be advised that the consultant radiologist reading fee is incorporated in the X-ray cost prior to taking a radiograph if the practice elects to manage their radiology department in this way. Finally, although the high cost of referral is often used to justify telemedicine as an alternate route, telemedicine is not meant as a substitute for referral. Instead, it provides a supportive resource to manage clinical cases alone. The attending veterinarian is in the best position to judge when a telemedicine consultation is relevant or when patient referral is most indicated, depending on the resources and skills at hand. In this regard, should an owner be reluctant to have their pet referred, telemedicine can be a first course of action giving the veterinarian the support he/she needs to manage the case in-house.

Choosing a telemedicine service

There are 3 main aspects to consider in selecting a telemedicine provider: (1) image formats and the quality of data or image transmission; (2) report quality; and (3) access to a multidisciplinary specialist group.

(1) Image formats and the quality of data or image transmission. The most important aspect in sending images to a remote specialist for a second opinion is adhering to official medical standards for data and image transmission. Imaging standards such as DICOM (Digital Imaging and Communications in Medicine) set guidelines and requirements for image transmission and ideally should be adhered to although some telemedicine providers accept radiographs in JPEG format. The DICOM standard is evolving constantly and not all imaging equipment or

software is DICOM compliant, so this needs to be checked by the veterinarian when purchasing new equipment. Even if devices are compliant, they may not incorporate the most recent updates to the standard (eg. DICOM version x.x; http://medical.nema.org/dicom/). When shopping around for imaging equipment, a practice should ask about the devices' DICOM compliance, the possibility to easily archive images remotely in order to backup the practice's images, and whether the software (worklist or PACS) allows the primary care veterinarian to configure different destinations so the clinic can flexibly choose a telemedicine provider or remote archive for storage.

For the specialist responding to a query, the challenge lies in the quality and completeness of the information provided, a selected subset of the information available regarding the patient. Is it appropriate to interpret information sent by a requesting veterinarian even if the images and/or data provided are suboptimal? Although suboptimal samples or requests cannot always be avoided, it is the role of the specialist or telemedicine provider to inform veterinarians regarding the minimal requirements for patient information needed and provide further guidance in order to improve future submissions. This is akin to quality assurance in the diagnostic laboratory and should be part of the telemedicine provider's policy.

Some techniques in diagnostic imaging lend themselves less well to remote image interpretation. Abdominal ultrasound interpretation requires a trained and knowledgeable driver - the sonographer - for proper evaluation and interpretation by the specialist. Many telemedicine service providers do not offer interpretation of ultrasound imaging for this reason, be it for still images or videoclips. Veterinarians using a service that does advise on such images should ask themselves if they really benefit from submitting them. Videoclips of the whole animal are very valuable in consulting the specialist and can be used in neurology consultations, assessing behavior or gait problems.

(2) Quality of the report

A high quality report does not only require a quick turnaround time but should also be subject to scrutiny (eg. peer review). Furthermore the consultants have to be trained in improving submissions by providing appropriate recommendations. High report quality that provides useful recommendations for the veterinarian is as important as, if not more so, than the turnaround time provided.

(3) Access to a multidisciplinary specialist group

The advantage of a dedicated telemedicine provider is that a large pool of qualified specialists in several disciplines is available to the clinic, ensuring short turnaround times, coverage for holidays or other leave by specialists, and makes use of a common, easy-to-use online platform. It also handles the billing, which can be centralised for a group of clinics, data storage and publicity. Sometimes, a practice may wish to work only with consultants they know personally which some providers respect and cater for.

Discussion

There are several benefits to incorporating telemedicine as a service in the clinic:

(1) Efficiency in case management – this minimises trialling therapies or performing diagnostic tests that may not be indicated;
(2) Competence is demonstrated by working with a remotely located multidisciplinary specialist team;
(3) Continuing education through working alongside a specialist colleague;
(4) An economic benefit from continued in-house case management due to additional diagnostic tests, treatments and contact with the client.

The online telemedicine consultation allows high quality images and detailed patient information to be exchanged quickly and for the veterinarian to receive a prompt response from a specialist. It also provides the veterinarian with a tailored approach to case management and the nuggets of wisdom from a specialist who has been exposed to a large number of complex cases, and the possibility to continue to interact with one or more specialists, as needed, if several disciplines are covered by the telemedicine provider.

Conclusions

There are a growing number of telemedicine service providers making online specialist support more accessible to veterinary practices. Telemedicine is an affordable additional service that practices can offer pet owners, especially if there are financial constraints regarding referral or if time is of the essence. The two main attributes of telemedicine are that it provides veterinarians the multidisciplinary support they might otherwise lack in a practice team and a means to managing cases more efficiently by improving the quality and speed of diagnostic and therapeutic decision-making. If used properly, more complete information is passed on to the specialist using this form of query, resulting in useful advice that enhances the quality of veterinary medical care in the practice, especially for more complex cases. Clients most easily accept it if it is implemented as part of the practice's services, showing pet owners that the practice has access to, and works with, a team of specialists.

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REPRINT PAPER (DK)

Health check for practising veterinarians

From James Herriot to New Professional Man – conditions for business succession in Danish veterinarian practices

Johanne Østerbye[(1)#]

INTRODUCTION

Focus in this and the following article will be on practising veterinarians as professional and self-employed business people, and the major challenges facing the profession – business succession in practices, with the next generation of veterinarians seeking leadership and new forms of organisation, at the same time as practising veterinarians experience declining faith in their professional judgement, and increased regulatory control. The trend is paradoxical in many ways, as it is accompanied by increasing social significance for veterinarians and other professions. Specialisation is on the ascendancy.

Danish practising veterinarians are facing a major paradigm shift in terms of their self perception. Regulatory control and the centralisation of power are forcing veterinarians into a new role, where public service functions may end up dominating professional veterinarian autonomy. At the same time, rationalisation of agricultural production, declining veterinarian student intakes, fewer graduates entering into rural practices, are demanding new approaches. Meanwhile, society is keenly watching the veterinary profession, as it are still expected to fulfil its classic virtues and champion animal welfare.

Based on in-depth interviews with senior veterinarians – practice owners – a health examination has been carried out for the Danish veterinarian profession. How are the new operating conditions impacting on practising veterinarians, and how is the desired business succession being achieved?

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16-18 Part II

Anamnesis

Practising veterinarians tell a story of change. The self perception – or professional identity – of practising senior veterinarians is closely linked to being a free agent, with authority grounded in their professional expertise, and autonomy in organising their work. These key identity factors have come under pressure from greater administration and control, and increasingly aggressive market forces.

Factors in Figure 1:

Regulatory authorities

Practice owners report a trend over the last 30 years towards greater control from regulatory authorities. The government has

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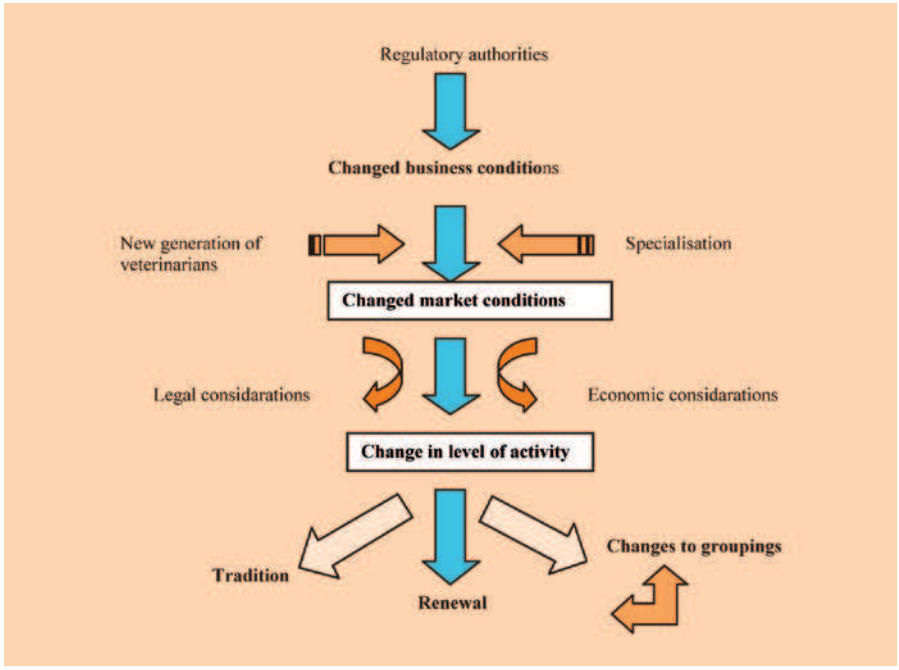
This article is based on the master's thesis of Johanne Østerbye (Consultant, Veterinarian, MPM, the Danish Veterinary Association) entitled, *"A new direction? Analysis of the veterinary profession – social conditions for business succession in Danish veterinary practises in the new millennium"*. The full thesis, and the theoretical and methodological background for the conclusions, are available in Danish on the website of the Danish Veterinary Association: www.ddd.dk



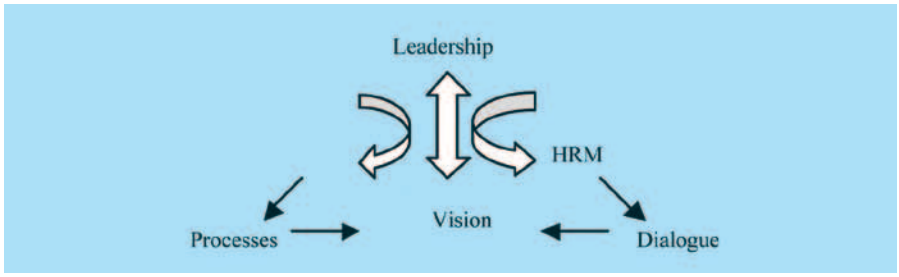


Figure 1 shows the development of the change process which becomes evident after working through notes from the in-depth interviews (see box).

Figure 1 has been derived using data from the qualitative interviews and shows the process of change taking place in veterinary practices, interaction with the outside world, and the possible outcomes of the process. Leadership has been given its own diagram (blue background). Assistants and practice owners agree that leadership will play a vital role in the final outcome. Leadership could, like an enzyme, serve as a catalyst for a faster, less resource-intensive and more deliberate path through the necessary process.

changed the framework within which large-animal veterinarians operate. Their relationships with colleagues in the Danish Veterinary and Food Administration are under strain. The authorities are seen as rigid rule enforcers who have forgotten the role of professional judgement. The conflict between professional autonomy and greater control is seen in the tension between regulatory authorities and professional pride. Increased administration is seen as a barrier to work satisfaction, succession in practice, and survival of the profession. Current practice owners are finding that requirements and regulation can conflict with the desires of new assistants for professionalism and autonomy.

Changed business conditions

Business conditions are linked to the government and political arena – conditions which impact on the operation of a veterinary practice as an independent business. The veterinarians' professional association is expected to play a role in this area through lobbying and strategic, proactive engagement in national politics. Veterinarians point to the current veterinary accord as evidence that their association is not working proactively. They concede that there is a certain signal value in standing outside the accord, but this achieves nothing and is seen as weak opposition. Rather it is the agricultural organisations which are seen as the strong players – the ones who have set the framework and changed the conditions for work in practices.

New generation of veterinarians

Veterinarians view their employees from their position as self-employed businessmen. Assistants are seen as employees who need to be trained – the farmers know more than a new veterinarian straight out of college. Assistants are also seen as not pulling their weight , until such time as they have bought into the practice as partners. Many practice owners feel that their assistants have favourable conditions. As a whole, they go one step further and describe the new generation as unwilling to invest and tie up capital in a future as a partner – due to concerns about family and leisure time, and because the entrepreneurial spirit senior veterinarians see in themselves is not very evident in the following generations.

Changed market conditions

These are the factors which together provide the external context within which the practice must operate. The changed business conditions are leading to greater competition, which may in future lead to the formation of first and second class practising veterinarians. Emergencye work will become less frequent, and consultation work in large-animal practices will be given greater focus. New regulatory requirements will make it quite an art in future to juggle the roles of *inspector* and *consultant*. There are also new conditions in relation to recruitment and business succession. The new generation of veterinarians can no longer be expected to simply follow the tradition of taking over the practice after two to five years as an assistant. They want a guarantee of professional content and financial security – and expect leadership and professional development during their time as employees, and later as a partner in the practice. The practices capable of meeting these new expectations will survive, according to those interviewed.

Legal considerations in relation to business succession

Many practices have enshrined future business succession within a strict legal and economic framework, as opposed to

Figure 2. Informants were asked to draw a pie chart showing how they spend their time in their practices. Administration accounts for an average of 24 per cent of informants' time.

operating within a loose framework.

Specialisation and economic considerations

The trend towards greater specialisation in livestock practice is mirrored in all professional areas, and may lead to the desire to invest in diagnostic equipment such as scanners, digital x-ray machines, dental equipment, etc – equipment which can require significant investment. In the larger affiliated practices and mixed practices, where several professional groups work together, all interviewees report increasing tension between solidarity with the practice as a whole, and solidarity with other specialists. Economic considerations are fuelling this tension. Actual and desired investments are often greatest within the companion animal and equine sectors, whereas livestock veterinarians can manage with the equipment which can fit in their work vehicle. There are concerns as to whether these investments are yielding the desired returns, as well as conflicts over whether groups are pulling their weight or freeloading. This is a central aspect in some affiliated practices, and the business organisation is structured around the economic framework. Commission-based remuneration systems are developed, time studies are carried out, and fee committees are appointed. Depreciation on equipment is being made personal. This is a clear break with practice structures in earlier times, where there was always trust that everyone was pulling together.

Change in level of activity

Administrative work accounted for a major proportion of daily activities for all interviewees. See Figure 2. In less than a generation, there has been a change in the distribution of tasks, from clinical towards more desk work and increased administration. Several practices report that regulatory control measures have led to stress and illness among partners. This quickly leads to a vicious circle of extra work and an ever increasing backlog. Many practices have also seen a decline in profitability due to the changes in the distribution of work. Where it used to be possible to manage several visits during a duty shift, administrative work now has to be taken into account.

Changes to groupings

A possible consequence of increased specialisation is the formation of new groups, centred around specialist fields and decision processes. Where decisions in the past used to be made via a democratic process involving all partners, the trend now is to delegate responsibility to a leadership group, such as a business committee or board of directors. In some practices there is a gradual slide away from large democratic meetings towards appointment of smaller groups to make decisions and implement them. Veterinarians report that bonds exist within these groups. The same is evident in the professional associations. One consequence of this change in focus may be the loss of team spirit within the businesses. This differentiation is expected to become more pronounced, with practice owners predicting that companion-animal veterinarians will be split into general practitioners and specialists. James Herriot, as an icon of the all-round practising veterinarian and symbol of the mixed practice based on democratic principles, will thus finally be laid to rest as a figure of the past.

Professional Man: Motivated by a sense of duty and the desire to maintain good professional standards. Relationships between people are based on professional standard practices.

Illustrations: Lars Hauritz

The future

This issue covers initiatives being considered and current actions in response to changes in internal and external conditions:

- New interdisciplinary alliances and plans for national consultancy centres providing both health and consultancy elements – meeting professional development requirements and the desire for "one-stop shopping" among livestock owners of the future.
- Amalgamation of livestock veterinarians into a joint company which manages the administrative component of the work, ongoing training, and marketing, to ease future recruitment and ensure continual development within these fields. This would permit a professional community to shoulder the burden of the detrimental consequences of external challenges, while also responding to the desire for professionalism and work satisfaction. Veterinarians would retain their local practices, whilst also being members of a nationwide professional network.
- Merging practices and employing internal leaders frees up more time for professional work. It also generates profit which can be used to employ more staff for the administrative component of the work. Leadership within the individual professional communities is a result of this trend.

Economic Man:
Motivated by material gain and relationships between people are contractual.

The aim is to ensure communication with board members/managers, and to prevent a breakdown in solidarity within the wider practice.

- Reflection on the role of management, and changes to the organisation such that the managing director is no longer a partner, but an employee.
- Fixed term employment for assistants, and linking additional shareholders to the company will counter the lack of commitment from senior assistants and help ensure the desired business succession takes place.
- Students are being invited to participate in job training within businesses, and foreign veterinarians are being employed to meet future recruitment needs and a possible increase in competition.
- Employing external veterinarians to do duty shifts, so the management and permanent staff can work as efficiently as possible during the day.
- Commission-based remuneration, time sheets and investment agreements are being used to counter concerns about economic inequality within practices, and the tension between the respective professional groups.

Management/Human Resources Management
All interviewees agreed that leadership was necessary. They have all witnessed the transition from the time of entrepreneurs with short chains of command. When companies grow it becomes necessary to have leadership. Leadership in this context is seen as a kind of "rocket science" – difficult to master. Problems with cooperation and poor team spirit are attributed to a lack of leadership. Several companies have met the challenge and appointed leaders within the various specialist groups who also serve as part-time veterinarians. Other companies have gone all the way and employed full-time leaders . The challenge is to be able to lead one's peers where cordiality among partners can be a barrier to a critical approach by the leadership.

Symptoms

Three leadership types have arisen as a symptom of changes within Danish practices. These are archetypes, and elements of the three leadership types and the quotations used have been drawn from in-depth interviews with senior practice owners. Examining the various leadership characteristics in relation to business succession in practices helps magnify and clarify how they are tackling the internal and external challenges. This will allow leaders of practices to make comparisons and assess the process of change and strategic readiness in their own businesses.

Economic Man
Motivated by material gain, and with a contractual approach to relationships:
"Things aren't going very well anywhere in Denmark. 85-90 per cent of fee income is paid out in assistant salaries. Our practice is a business, and we have to earn money wherever we can".
There is a fight for market share, and the enemy are the competitors:
"As long as an assistant is profitable, things are OK. If we are losing money on an assistant, this is unsustainable. Either the assistant has to go elsewhere, or do less".
This type of leader wants to make their own decisions without interference from others. There is a focus on business development and competitiveness. They are highly active, willing to take risks, and invest time and energy in good business acumen. They feel the regulatory authorities are giving veterinarian practices completely unreasonable conditions under which to operate a business. The authorities are continually inventing new regulations, and snuffing out the desire of veterinarians to run a business. They see the greatest future challenge as lying in this area. If veterinarians were simply left in peace to be enterprising and create jobs, business succession and survival would be ensured.
Economic Man is therefore a true reflection of the New Public Management initiatives which characterise the government's neoliberal reform agenda. Individual contribution-based reward formulas are being introduced in the affiliated practices, and there is a focus on the market. The veterinarian is a professional consultant. There is mistrust of the government and its control systems, and trust between colleagues is maintained through contracts. There is an ambivalence towards leadership. It is a necessary evil if the practice is to survive. The solution is to employ managers to lead the various professional groups, to maintain solidarity and ensure communication upwards to the board of directors.

New Professional Man: Motivated by professionalism and doing the right thing towards others – whether related parties or society in general. Relationships between people are based on dialogue and convenience.

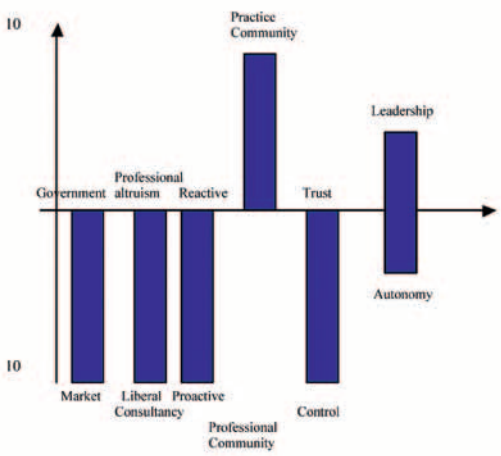


Figure 3. Economic Man's position between the poles of the various tension areas

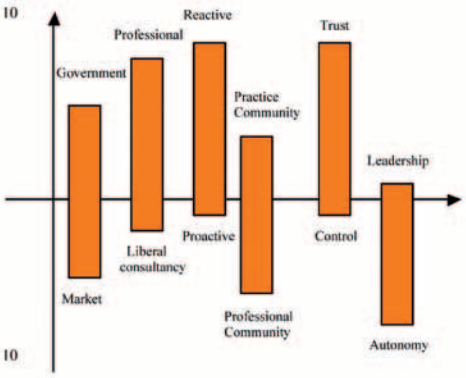


Figure 4. Professional Man's position between the poles of the tension areas.

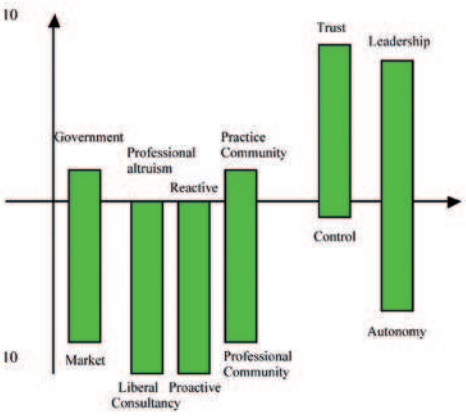


Figure 5. New Professional Man's position between the poles.

Professional Man

Motivated by a sense of duty and the desire to maintain good professional standards. Relationships between people are governed by professional standard practices:

"Being able to perform an operation in peace and quiet is wonderful. We had two displaced abomasums yesterday. There has to be time for coffee afterwards. There is half an hour of consultation, and an hour of coffee time. This shouldn't be changed".

"They are given a free rein, we have pretty much equal status. We do not set the assistants any tasks which are assistant work as such. They can speak their mind. We sometimes praise their efforts".

This group is fighting for conditions under which they can work professionally and independently, and the enemy is bureaucracy.

Professionals are doing much the same as they always have. There is no fundamental desire to change things. Each veterinarian has their own niche within the practice, which they stick to, even if market conditions change. They take a reactive approach to the market. There is no great desire to see growth or development outside the scope of the strictly professional elements within their niche. Contact with the market and peers has traditionally been via the local associations, which are reaching the end of their useful life.

It is important to this group that the business has a stable economy. They are averse to risk. Regulatory controls and increased administration are seen as nuisances, as they limit the time available for professional work and generally disrupt the routines veterinarians have developed.

New Professional Man

Motivated by professionalism and doing the right thing towards others – whether related parties or society in general. Relationships between people are based on dialogue and convenience.

"We sometimes look at each other's papers and ask, 'why do it this way when it would be easier to do it that way in terms of the technical elements'. We discuss treatments with each other. We also do 'second opinion' visits. If one person has a problem and is not making progress, we might send out someone else".

This group is fighting to find the common ground that makes sense, and the enemy is a lack of pluralism.

"Even though you are working in a small practice, you can still be part of the nationwide specialist community. We talk about recruitment for livestock practice in this forum. I personally find it very satisfying working with livestock. These reports help you to see correlations that you had no idea existed".

The group has a pragmatic attitude to the authorities and increased controls. As long as it makes sense professionally and for society, it is not completely futile. However, inflexible inspectors who stubbornly stick to their guns cause frustration, as New Professional Man feels that their colleagues in the Danish Veterinary and Food Administration should be more just and keep the aim of the controls in mind.

New Professional Man sees that market conditions are changing dramatically, and that it is therefore necessary to find new opportunities in terms of services and suppliers, as well as in terms of new alliances. He has a proactive approach to the market. He has many formal and informal contacts with others in private practice, and is happy to work with others across the established practice community. In other words, New Professional Man sticks to the primary practice community and services which work and are a source of job satisfaction, but also looks outside and reflects on the changes to life and working conditions within new communities. As the owner of a small business, New Professional Man can see that it is necessary to find new collaborative partners to ensure survival.

Diagnosis

Based on the anamnesis and symptoms we can identify the following tensions:

- Government versus Market
- Altruism versus Consultancy
- Market approach – Reactivity versus Proactivity
- Practice Community versus Professional Community
- Control versus Trust
- Leadership versus Autonomy

Therapy
The aim of this check has been to investigate the state of health in Danish practices in relation to succession in business. A business succession that can ensure practices survive – either in the traditional sense or in a completely new form. The proposed therapy consists of strategic recommendations. The various leader types find themselves attracted to one or the other pole in the various tension areas, depending on their perceptions of reality. The therapy will therefore depend on where they sit in relation to these tension areas.

Economic Man
The therapy aims to ensure employees have the right core skills in relation to the market. Focus group interviews with assistants reveal that the younger generation of veterinarians do not give a central place to clients and a market-oriented approach in their interpretation of future practice. New work routines will therefore be required which give focus to clients within the organisational structure. Sustainable financial results are achieved through a balance between professionalism, client service, responsiveness to changes in the market and financial common sense. The goal for Economic Man must be a better balance in priorities. A one-sided focus on profit and individual contributions can create detrimental behaviour patterns. Focus group interviews show that professional focus and pride among the younger generation are well-established and reminiscent in many ways of the original altruism. A purely economic value set may therefore have a directly demotivating effect and potentially derail the business succession.

Professional Man
The therapy targets holistic organisational considerations, taking into account the desire of assistants for social satisfaction outside working hours, and making allowance for the professional communities. Professional Man is the successor to James Herriot – the traditional veterinarian with altruism, professional autonomy and pride. His core focus is the primary professional expertise, making these businesses fairly successful in attracting the new generation. Solidarity within the practices is based on trust, and everyone pulling together. However, the problems arise in relation to organising the work. The older generation has often been used to everyone taking care of their own responsibilities, and this attitude does not support the new generation's demand for professional development and expectation of 'apprenticeship' or a mentor. External leadership may be able to achieve the complex challenge of grafting employees into the business, given that there is no team spirit to draw on. Such leadership can also set a more strategic and proactive approach to the market. The situation may arise in these businesses that time stands still in relation to development; a form of stagnation.

New Professional Man
The therapy and strategic recommendations target two areas: the future leadership, and the tension between professional communities and the original practice communities. With respect to leadership, veterinarians in the communities should consider employing an external leader, as leadership within a professional collective often makes real leadership impossible. There is a danger of repeating behaviour patterns linked to the traditional profession's ideologies of equality and practice operations.
Given specialisation and generally increasing level of education within the profession, veterinarians should consider whether it is possible in the long term to be effective members of both the practice community and the new professional community. They should consider whether external and market conditions point towards new organisational structures, where focus can be given internally to the training and professional development of assistants and partners. A new organisational structure may meet the desire of the new generation to develop their expertise within a framework which also allows time for other social commitments, through efforts to provide contemporary services to the market.
The interdisciplinary approach which some of these new communities already pursue can counter the harmful aspects of the competition and rivalry between, for example, consultants and veterinarians. This could in turn have an influence on the power struggles within the political arena, where new alliances could pave the way for a new perception based on trust rather than control.

Prognosis

Changes within the deregulated knowledge society are impacting on the identity and future forms of practice for the veterinarian profession. The practising veterinarian, as an institution, is undergoing change. Throughout this process, the image of the veterinarian stands as an unclear mix of obsolete authority, the long arm of the government, and a local businessman. This unclear mix also results in a loss of legitimacy – in terms of what is "desirable, proper and appropriate" – in other words, credibility. If the necessary future business succession is to take place, and the profession is to survive, there is an acute need for reflection and change.
This change can take place gradually, or through revolutions. The change can be brought about proactively by the veterinarians involved, before others go behind their backs due to lack of initiative. The change can be created locally and only influence a few involved parties, or it can spread and impact others, and possibly even society as an institution.
Identity and image can blend together to shape a professional consultant who offers his professional insight and experience on market terms, in interaction with the client. New Professional Man could become the focal point for the necessary change in practices.

New norms and new directions

What key factors will lead the coming generation of veterinarians to become partners in the practice community?

Johanne Østerbye

The way work is organised is critical to how assistants perceive their role in clinical practice. Work segregation and procedures have dramatic effects on dedication and motivation. This was the general message from assistants who participated in a number of focus group interviews aimed at investigating conditions for business succession in Danish veterinarian practices in 2009 (see box). According to these assistants, reorganisation can be used to lever improvements in other areas.

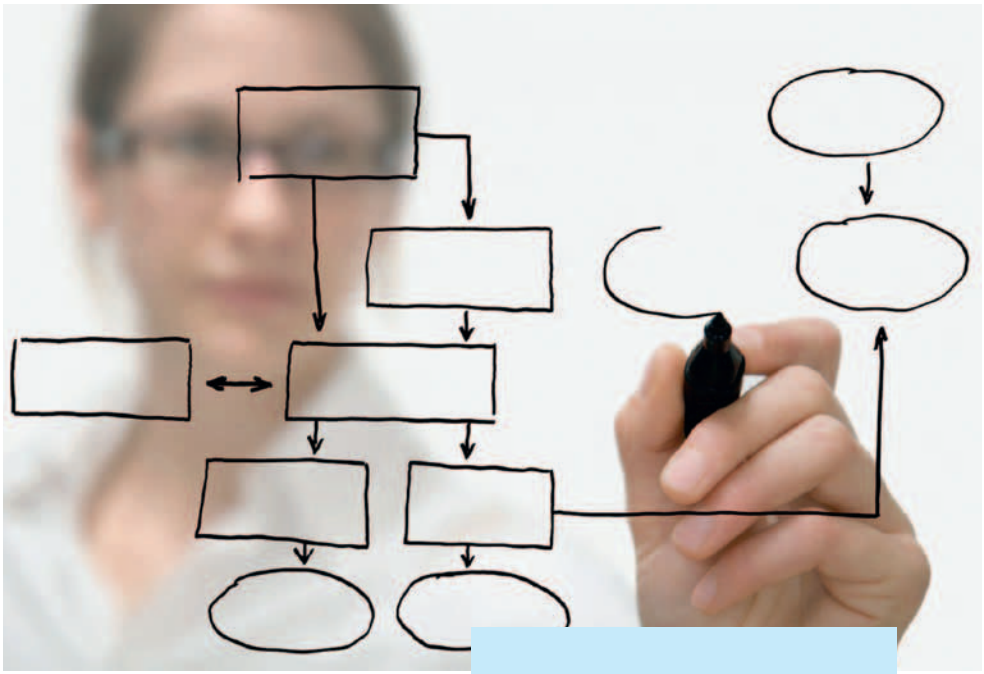
For example, practices can facilitate the difficult harmonisation of family and working life by restructuring the working day. By focusing on specialisation and professional development, and moving towards larger units[1] with more employees and an appropriate organisation design, new values can be introduced into practices. This should ideally be guided by an overall vision, with professional leadership directing and catalysing the ongoing process.

"A high degree of specialisation, so you don't have to be good at everything".

"A good working environment – able to delegate and know precisely who is responsible for each task".

The justification in relation to the impending business succession and the current practice owners is that workplaces which can offer full professional development through knowledge sharing with colleagues will attract the new partners of the future. The challenge for some practices is to effect a personnel policy and organisational structure which allows assistants to retain their professional identity, and sets new standards for harmonising family and working life.

It will be up to leaders to serve as role models and "walk the talk" in their daily work, so the assistant can see a future as a partner in the practice. Efforts to improve the organisation will impact on values, and if leaders go home at 5:00 p.m. each day and ask staff to switch off their mobile phones, this expresses basic conflicting values in terms of the priority of work in each veterinarian's life.



Changes to practices and their conditions

The focus group interviews also revealed that changes in operating conditions for practices, along with new structures and procedures affect behaviour and can lead to unexpected negative side-effects. Increased administration requirements resulting from greater regulatory control are managed in some practices as extra work which assistants and partners simply have to find time for during their working day – or in their leisure time.

Assistants' attitudes to successful business succession

Five focus group interviews with assistants from various forms of practice throughout Denmark provide the basis for the analysis and subsequent conclusions presented in outline in this article.

Thanks to The Danish Veterinary Practitioners Association and Capacent for good teamwork and subsequent access to in-depth analysis of notes from the interviews. Thanks to the Danish Veterinarians Insurance Association, under Codan/SEB, for kindly supporting the master's thesis entitled, "A new direction? Analysis of the veterinary profession – social conditions for business succession in Danish veterinary practices in the new millennium" by Johanne Østerbye, MPM, veterinarian.

Other practices reorganise their daily operations to take into account the extra administrative workload.
New wage and evaluation systems can be designed with the best intentions, targeting increased efficiency and the fair distribution of income in line with effort, but such systems can lead to mistrust and unintended behaviour patterns among employees. In some cases, assistants have resigned as a consequence.
"I was told brusquely that I had hardly earned enough to cover my salary over the last few years. I resigned immediately! Because they did not appreciate the other ways in which I had contributed. They were only interested in the financial side".

Paradoxes and areas of tension

The assistants in the focus group investigation all agreed that sufficient earnings are the foundation for everything else. A healthy economy makes it possible to employ others to perform the tasks which lie outside the purely professional area, reducing working hours for veterinarians, thereby leaving room for reflection and development.
A vicious circle will quickly arise in practices where veterinarians perform all the tasks themselves, do not pursue professional development because of time pressures, and are forced to focus on price instead of quality as a competition parameter.. The practice will degenerate into an economic prison which assistants describe as the worst imaginable scenario in a future as a partner.
It therefore seems paradoxical that clients who are the source of the desired income are viewed as a burden and a problem by assistants.
"I think it is very important to agree on how to manage the clients, because then it happens automatically, and there is a united front. This is what works. There are major differences from practice to practice in terms of how clients are trained".
The majority of assistants do not see it directly as their job to link developments in the market and developments in practices. Skilled employees who are responsive to feedback from the recipients of their services will therefore be a key resource among those striving to ensure practices remain in the marketplace.
There is much to suggest that work routines, perceptions and values do not support the necessary market focus – that attitudes to organisation, professionalism and basic faith and values among assistants in Danish veterinarian practices are disconnected from an appreciation of the market. The assistants write the clients out of the equation!
The self perceptions of most young veterinarians are primarily linked to the expertise, professionally grounded authority, and autonomy in arranging work which has historically been associated with the profession. A self perception which belongs to the original altruism, and which they carry with them from their time of study at the Faculty of Life Sciences at Copenhagen University.

Social factors and the leadership challenge

It is surprising how little reference is made to social factors in the focus groups. The young assistants seek professional guidance from their supervisors, but apart from experiencing a lack of basic apprenticeship, they make no mention of a desire for group dynamics, loyalty, or "esprit de corps".
Social aspects are expressed in the desire for a change in organisation which permits leisure time for social relationships with family and friends. One could argue that the desire to belong is expressed when they seek involvement and transparency in financial matters, but this could also be interpreted as a desire for utility and material gain, or a fear of not knowing all the risks before making a decision.
The autonomy enjoyed by practitioners sets the scene for the "leadership challenge" in the future predicted by assistants. Professional judgement – drawing on a combination of experience and theoretical knowledge, often without reflecting on it at the time – has *not* created a basis or tradition for reflecting on one's actions and their consequences for affected parties, including staff and peers.
This professionally grounded authority is carried over, unnoticed, into other relationships of life, and it can be difficult for a veterinarian with a traditional self-perception to accept and openly acknowledge that they make mistakes. This factor makes it a significant leadership challenge to lead or advise autonomous veterinarians in their daily work.
"But these seven leaders – are they capable of reporting to a managing director?".
Even so, assistants seek professional leadership in their daily work.
"An administrative person should be employed. I don't feel our education has prepared us to be leaders – at least not the way I see things now. It is the veterinary work I find appealing. I should be spared from all administration".
Thus faith and vision are left up to the *leadership*. The assistants basically want to be left in peace to be practitioners– even when they become partners. The leadership has to create the desired vision for the future, and communicate this to employees and peers. The leadership challenge will be threefold:

- The leader has to integrate employees and peers into the organisation, without having solidarity or a loyal work ethic to fall back on.
- The leader also has to open the practice to the outside world and get in touch with the interests of clients and livestock owners in the marketplace..
- The leader must know each employee and peer so well that client requirements can be met in a way that fully exploits the available potential.

The question is, who is going to meet the leadership challenge in Danish veterinarian practices in the future ?
The focus groups refer to *leadership* as a hypothetical concept and not an existing reality[2], and we might ask where this leadership mantra comes from. Veterinarians have traditionally been autonomous within a professional hierarchy at the clinics, without the need for additional supervisory coordination. The logic can be recognised as one of the key arguments in New Public Management[3] regarding leadership:
"There is a focus on professional, entrepreneurial leadership with a vision and a mission, which can be held responsible for implementation of new initiatives. Leadership is moving away from the administrator and professional focus, towards leadership teams which function as strategic forums".

Business succession and the future shape of practices

The change currently taking place in society, and among practising

veterinarians, is reflected in the new generation and their desire for change in practices. The regulatory structures resulting from the neoliberal forms of control – most recently in the form of the veterinary accord – may lead to changes in ethics and practice among the coming generation of veterinarians.

Such a control strategy may force the new generation of veterinarians to give up their professional autonomy, given that it is difficult to support. It is conceivable that repeated patterns of behaviour will eventually lead to new norms and values, such that the current form of practice is changed. One possible scenario might be that practising veterinarians become part of the public health sector. This will require a paradigm shift for practitioners, away from their original status as an independent profession. Another possibility is that veterinarians construct an alternative form of practice which decouples the fixed rules from professional judgement, and renegotiate their autonomy.

The question, then, is whether the profession should sit by and let New Public Management and neoliberal forms of control provide inspiration and set the agenda for others, including civil servants within the Danish Veterinary and Food Administration. Should we let them have the initiative and set a new direction for the profession under the cover of the process of change? Or should we identify it ourselves, and let our own entrepreneurs lead the way, by choosing a strong organisational value base built on professionalism and trust?

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[1] A quickpoll targeting PDAs shows a trend towards a break up in the existing practice structure. Only five out of 50 current partners in mixed practices expect these to continue to exist in the future.

[2] A quickpoll of practice owners found that 90 per cent of respondents believe that leadership will be necessary in practices of the future, and that people other than veterinarians would be able to provide this.

[3] New Public Management is part of a neoliberal reform wave – an international megatrend – where the reforms of the 1990s up until today are described as a virus affecting the West, and as a "burning issue" necessary for socio-economic development by the World Bank and OECD. (See the thesis entitled: "A new direction? Analysis of the veterinary profession – social conditions for business succession in Danish veterinary practices in the new millennium" on the website of the Danish Veterinary Association: www.ddd.dk > PDA > Management og ledelse).

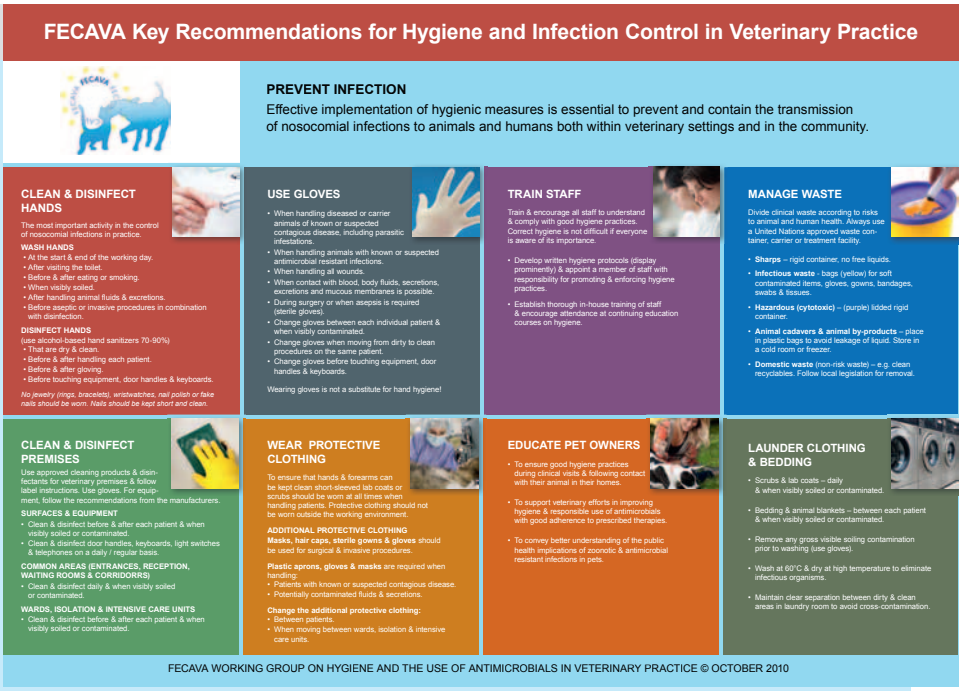
The FECAVA Symposium 2010*

Hygiene and Antimicrobial Resistance

INTRODUCTION

The FECAVA Hygiene and Antimicrobial Resistance Symposium was held during the FECAVA / WSAVA Congress in Geneva last June. As this is an issue of global concern we were happy to invite some of the world´s most well know speakers on the subject. The Symposium was attended by a large number of delegates and the lectures were very much appreciated.

A nosocomial infection is an infection, not present or incubating on admission but acquired in the hospital. The transmission of a pathogen can occur through the environment, between staff and patient or between patients, through direct or indirect transmission. This is an increasing problem not only in human hospital settings but also in small animal practice. One of the most serious nosocomial transmissions is that of infections caused by antimicrobial resistant bacteria such as methicillin-resistant *Staphylococcus aureus* (MRSA) and methicillin-resistant *Staphylococcus pseudintermedius* (MRSP). Infections caused by pathogens resistant to antimicrobials can cause serious disease in both humans and animals.



Effective implementation of hygienic measures is essential to prevent and contain the transmission of nosocomial infections to animals and humans both within veterinary settings and in the community. Every veterinary practice, no matter what its size, should have a person responsible for infection control. There should be hygiene guidelines posted and adherence to basic hygiene routines should be an integrated part of all clinical work.

Appropriate selection and usage of antimicrobial drugs in veterinary settings is also vital to maintain the efficacy of antimicrobial treatments in companion animals and to constrain antimicrobial resistance that can seriously compromise animal health and welfare and can have negative implications for public health.

As veterinarians we all play an important role in the prevention and treatment of diseases in small animals but also have a responsibility in the education of animal owners. Communication with pet owners is essential to raise awareness of potential health risks and to ensure their active involvement in the prevention of bacterial, viral and parasitic diseases and their compliance to prescribed therapy to pet animals.

To publish papers in EJCAP based on the lectures given at the FECAVA Hygiene and Antimicrobial Resistance Symposium is an important part of the continued work to increase awareness on this emerging matter. All the papers will be posted on the FECAVA website (www.fecava.org) together with the poster "FECAVA Key Recommendations for Hygiene and Infection Control in Veterinary Practice". This poster (above) shows the different key elements in basic hygiene within veterinary settings. It is free to download. The appropriate printing size is A2. Translations into different languages are available on request.

Alexandra Vilén, DVM, FECAVA Director of SSAVA, Chair of the FECAVA Working Group on Hygiene and the use of Antimicrobials in Veterinary Practice

*Held during the 16th FECAVA Eurocongress SVK/ASNPA Congress Geneva 2010

MRSA in humans – epidemiology and clinical importance

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INTRODUCTION

Methicillin-resistant *Staphylococcus aureus* (MRSA) has caused much concern among health-care professionals, considerable fear among the general lay public, and a large number of newspaper headlines touting a "superbug". Why has this pathogen received so much attention?
S *aureus* –whether resistant or not – is first of all a human commensal, asymptomatically colonising the anterior nares and moist areas of the skin of 30% of humans [1]. But S *aureus* can also cause invasive infections. The skin is most commonly affected. Skin and soft tissue infections can be relatively trivial and superficial (impetigo), or more serious and invasive (cellulitis, abscesses). Infections of deep-seated structures such as the lungs or bones are often complicated and difficult to treat. At the most serious end of the spectrum, S *aureus* causes bacteraemia and endocarditis, life-threatening infections that few patients survived prior to the advent of antibiotics.
Based on the clinical presentation of a patient it is impossible to predict with certainty whether an infection is caused by MRSA or MSSA (methicillin-sensitive S *aureus*). While methicillin-resistance does not render S *aureus* more pathogenic *per se*, it seriously limits treatment options. In addition, antimicrobial resistance seems to be preferentially acquired by S *aureus* strains that are "successful" epidemiologically [2].

Historical perspective

The advent of penicillin in the 1940s revolutionised the treatment of S *aureus* infections and considerably improved the outlook for affected patients [3]. However, penicillin-resistant strains emerged rapidly, and by the middle of the 1950s penicillin had lost much of its usefulness as an anti-staphylococcal agent. Much of this was due to one strain, the 1950s equivalent of today's MRSA: A penicillin-resistant S *aureus* clone designated phage-type 80/81 that was particularly virulent and highly transmissible and that caused difficult to control hospital outbreaks [4]. In one Boston Hospital the mortality associated with S *aureus* bacteraemia increased almost five-fold between 1947 and 1957 due to the spread of antimicrobial resistance while the mortality from pneumococcal bacteraemia was falling [5].

In 1959, methicillin, a new penicillinase-fast semi synthetic antibiotic promised renewed control over S *aureus*. In fact, around the same time phage type 80/81 started to disappear. However, it took less than two years from the introduction of methicillin that the first MRSA was isolated. Soon, MRSA became a significant clinical problem, particularly in Europe. In countries like Denmark and Switzerland up to 30% of S *aureus* isolates from blood cultures were methicillin-resistant in the second half of the 1960s. By the 1980s these archaic MRSA strains had vanished into thin air. It is unclear whether this was due to successful infection control measures, introduction of new antibiotic agents, or other reasons [6]
In the meantime a second wave of MRSA was underway. A number of strains – different from the ones seen in the 1960s – spread in hospitals and long-term care facilities all over the world. In England, for example, over 40% of all S *aureus* blood culture isolates were MRSA in 2000. Different geographic regions are affected by different strains of MRSA, which may in part explain the hugely variable success of MRSA in different countries.

Why is MRSA a problem?

S *aureus* is a virulent organism that causes considerable morbidity and mortality. The MRSA strains that became endemic in hospitals since the 1980s share this property. In addition they appear to be particularly well adapted to the contemporary hospital population and environment. They are associated

with older age, more co-morbidities, previous hospitalisations, surgery, and invasive devices. Due to their antimicrobial resistance they have a selective advantage over other microorganisms in the face of widespread use of broad-spectrum antibiotics. Hospital MRSA strains are highly transmissible and spread within and between health care facilities. Finally, resistance to first line antibiotics may necessitate the use of more expensive second or third-line agents, increasing the cost of treatment [7-8]

Particularly well adapted to hospitals, hospital MRSA strains are a very common cause of health-care acquired infections. Figures from the United States implicate S *aureus* in 30% of surgical site infections (49% of isolates MRSA), 24% of ventilator-associated pneumonia (54% MRSA), and 10% of central-line-associated blood stream infections (57% MRSA) [9]

How can MRSA be controlled in hospitals?

The control of MRSA in health-care facilities demands a multi-pronged approach, similar to other health-care associated infections. First, the problem needs to be measured, described and defined. Surveillance leads to increased awareness and helps to focus minds. Second, steps have to be taken to reduce transmission, including consistent hand hygiene with alcohol-based hand rubs for staff and isolation or cohorting of MRSA-colonised patients [10]. Third, patient-level risk factors need to be tackled. Examples include managing the risk from central lines by adhering to evidence-based care bundles and reducing the risk of surgical site infections through best practices in skin preparation, antimicrobial prophylaxis and surgical technique. Fourth, ecologic factors have to be addressed, such as reducing and optimising antimicrobial consumption and cleaning. A strategy aimed at identifying MRSA carriers on admission by universal screening has contributed to the Dutch success in keeping MRSA rates minimal, [11] but its merit has not been conclusively judged in settings where MRSA is endemic [12-13]. Targeted screening is useful in both endemic and non-endemic settings.

The success of these measures has been demonstrated, and the incidence of MRSA infections in hospitals has been falling in several countries in recent years [14]

A new threat – community-associated MRSA

The fight against the MRSA strains commonly found in hospitals has been facilitated by the fact that transmission of these strains largely occurred within health-care facilities, and endeavours to curb their spread could be focused accordingly. Unfortunately, since the 1990s strains of MRSA have emerged that primarily circulate in the community (CA-MRSA) [15-18]. These community-associated clones appear to have a higher biological fitness than hospital strains and are often more virulent. As a result, they also affect young, healthy individuals in whom they cause serious skin and soft tissue infections and, more rarely, pneumonia. In many US emergency departments, the majority of adults presenting with staphylococcal skin and soft tissue infections are affected by CA-MRSA [18]. Compared with the "conventional" hospital MRSA strains, CA-MRSA are usually resistant to fewer classes of antibiotics. Oral drugs such as clindamycin, tetracyclines and co-trimoxazole frequently remain active. However, alarming trends of increasing resistance have been noted [19]. Control of these strains is much more challenging as they are not limited to health-care facilities. As time goes by, the borders between hospital- and community-associated MRSA are becoming more blurred, and CA-MRSA is increasingly becoming endemic in hospitals in several countries, such as the United States, Greece, Algeria, India, and Taiwan (among others).

The role of animals in human MRSA infection

Pets have anecdotally been implicated as reservoirs for human MRSA infection [20]. More recently, livestock has been shown to act as a source of MRSA. A novel strain, ST398 has been found to be highly prevalent in pigs and calves in Europe and North America [21-22]. Persons who are in direct contact with livestock frequently become carriers of this MRSA strain that is typically resistant to tetracyclines – a commonly used class of antibiotics in pig farming. Like other strains of S *aureus*, ST398 is capable of causing serious infections in humans [23].

For the time being, livestock-associated MRSA does not seem to be well adapted for human-to-human spread and is therefore mostly limited to individuals with direct contact with colonised animals [24]. Nevertheless, smaller hospital outbreaks have been reported, [25] and ongoing vigilance seems warranted.

Conclusion

MRSA is not a single entity, but represents a variety of clones of antibiotic-resistant S *aureus* with different epidemiological and clinical characteristics. Much progress has been made in controlling the hospital-associated strains that have plagued health-care facilities in many countries since the 1980s. Community-associated MRSA strains are a cause for concern, as these strains are associated with higher virulence and biological fitness. Animals can play a role in the epidemiology of human MRSA infection. Risk factors that promote the spread of MRSA in animals have to be identified and addressed.

Acknowledgement

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Stewardship of antimicrobials and hygiene protocols in practice. Are we there yet?

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INTRODUCTION

Antimicrobial resistance is nowadays a major public health issue. Misuse of antimicrobials is one of the risk factors associated with the development and spread of antimicrobial resistance in humans and animals. Furthermore, it is also linked to the occurrence of nosocomial infections in humans and it is becoming more frequently detected in veterinary practices. Monitoring and surveillance of antimicrobial consumption and resistance trends are important to inform policy makers and veterinarians for the development of guidelines and practice protocols, respectively. Stewardship of antimicrobials, together with infection control and hygiene programs are essential in veterinary practices to ensure and maintain efficacy of existing antimicrobials. Furthermore, responsible use of antimicrobials, hygiene and infection programmes are essential to contain antimicrobial resistance and nosocomial infections. This paper will focus on the development and implementation of stewardship programmes for the responsible use of antimicrobials and hygiene protocols in small animals practices.

Antimicrobial resistance issues in small animal practice

Antimicrobial resistance (AMR) is a global public health concern and it is associated with antimicrobial usage in both human and veterinary medicine. Currently, information is scarce on the extent and the patterns of antimicrobial usage in companion animals and on prescribing practices by veterinarians. Little is known about the role of companion animals, particularly dogs and cats, in the epidemiology of AMR, although there is growing evidence of antimicrobial resistance in pathogens with zoonotic potential in these species. Previous research has shown that companion animals can act as potential sources of infection for humans in veterinary practices. Also, at community level, companion animals can transfer resistant pathogens and AMR determinants to humans through social interactions and by sharing common areas [1, 2].

Veterinary surgeons, generally, are aware of the possible occurrence of adverse reactions when administering or prescribing antimicrobials. Allergic reactions to certain antimicrobial groups (e.g. penicillins) and growth abnormalities (e.g. fluoroquinolones) are well documented in the veterinary literature [3-6]. However, practitioners often fail to consider AMR as an adverse reaction and to consider it when selecting antimicrobials for animal therapy (Fig. 1) [7].

Surveillance of antimicrobial usage and of antimicrobial resistance (AMR) in companion animals

Knowledge of the extent and patterns of antimicrobial usage in companion animals is vital to the understanding of the context in which AMR occurs in these species. Data on antimicrobial usage at practice level can be used in risk assessment and risk management of AMR. Surveillance systems are important to gather data at both national and international level. However,

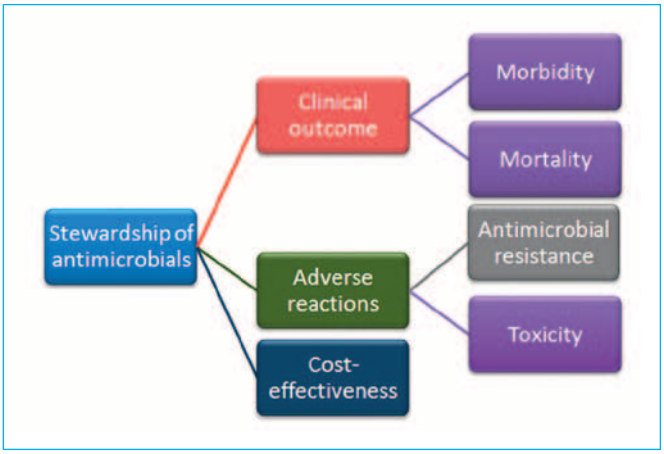

Fig. 1 Aims and objectives of antimicrobial stewardship programs.

The help of the FECAVA Working Group of Hygiene and Antimicrobial use in Practice is gratefully acknowledged. The group consists of: Ana Mateus, Didier Carlotti, Ulrika Grönlund-Andersson, David Lloyd, Katerina Loukakis, Peter Murphy & Alexandra Vilén

most of the currently available surveillance systems in different European countries are mainly focused in food-producing animals and gather very little information on companion animal species, especially when assessed by the level of wholesale sales of medicines. [8-10]. Recent studies evaluated antimicrobial usage through the analysis of clinical electronic practice databases or through postal survey of veterinary surgeons and identified widespread use of broad-spectrum antimicrobials, particularly of beta-lactams, fluoroquinolones and macrolides [11-16]. In the UK, the Royal Veterinary College in association with the University of Sydney are currently developing a system for the surveillance of diseases in companion animals in the UK, known as VEctAR (Veterinary Electronic Animal Record) (http://www.rvc.ac.uk/VEctAR/) [17]. This system will use, retrospectively, clinical data from electronic patient records of participating veterinary practices to assess disease prevalence but will also use research studies focused on pharmacovigilance and investigations of the efficacy of antimicrobial therapy [12, 18].

The European Medicines Agency (EMA) has recently implemented the European Surveillance for Veterinary Antimicrobial Consumption (ESVAC). This system monitors antimicrobial sales at the level of the pharmaceutical companies for the different veterinary species [19]. Nevertheless, most European countries have, currently, only a limited surveillance or monitoring of antimicrobial usage in small animals. Researchers in Denmark have referred to the importance of monitoring AMR in indicator bacteria (*Enterobacteriaceae* and *Enterococcus* spp.) in dogs, after observing that the use of fluoroquinolones and cephalosporins in this species was higher than in food-producing animals. These bacteria can be a source of AMR to human pathogens [20].

Currently, most of the AMR reported in companion animals refers to diseased animals monitored at practice level [1, 21-26]. Nonetheless, there is evidence that AMR also occurs within healthy companion animal populations and that pathogens with zoonotic potential are often involved [27-29]. Surveillance of such AMR in companion animals is important to assess the potential risk for public health and to identify areas for intervention, particularly for targeted antimicrobial stewardship programs.

Aims and objectives of stewardship of antimicrobials

Stewardship of antimicrobials is important in companion animal practice to prevent the loss of efficacy of antimicrobials due to the emergence of AMR and to prevent the emergence of antimicrobial resistance in pathogens relevant to animal and public health. Furthermore, stewardship programs are important to reduce morbidity, mortality and additional cost associated with resistant infections and therapeutic failure (Fig 1) [30]. Antimicrobials are used routinely in practice and are important tools for the prevention and therapy of infectious bacterial diseases in pet animals. However, veterinarians working with companion animals may not be aware of the impact that their use of antimicrobials has in society. This lack of awareness has been previously described in human medicine and raises ethical issues [31, 32]. The veterinarian has an "obligation" to provide the best medical care to their patients and to ensure their health and welfare. On the other hand, misuse through underuse, excessive, inappropriate and unnecessary use both in administration and prescription of antimicrobials in veterinary practice, can cause and lead to the spread of resistance in zoonotic pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA) or methicillin-resistant *Staphylococcus pseudintermedius* (MRSP) [31].The selection of antimicrobials less likely to cause AMR for treating an animal may involve selecting one that can be equally effective as the first choice antimicrobial therapy [33]. However, on certain occasions, it possibly may not be as effective as the first choice and can lead to therapeutic failure, compromising the health of the individual animal [34]. Therefore, careful consideration of available antimicrobials and their properties is needed when selecting animal therapy, so that the antimicrobial selected will be efficacious to treat the animal while having a low or no impact in AMR.

Criteria for the selection of antimicrobials

The decision-making involved in the selection of antimicrobials for the treatment of animals is a complex process that often has to be made during the limited time available at an animal consultation. Appropriate antimicrobial usage involves the selection of the antimicrobial based on the infectious condition or infectious agent involved, the correct dosage, the frequency of dosage and the duration of therapy through the most adequate route of administration, in order to obtain the therapeutic concentration at the site of infection [35].

Selection of antimicrobials should follow, whenever possible, an evidence-based approach, taking into account the findings of a clinical examination and tests performed but it should also be supported by the scientific evidence available from the published research. The veterinarian must take into account several requisites to choose the appropriate antimicrobial substance. These include the characteristics of the animal patient (species, age and immune status) but also the potential pathogen(s) involved (pathogenicity, virulence and antimicrobial susceptibility) (Fig. 2). Furthermore, the veterinarian needs to take into consideration the characteristics of the antimicrobial itself. These include: a) spectrum of action, b) mode of action (bacteriostatic or bactericidal), c) penetration (lipophylic or hydrophilic), d) pharmacokinetics and e) pharmacodynamics of the antimicrobial considered.

However, it is not always possible to obtain a definitive diagnosis from clinical examination and the clinician's knowledge of infectious diseases. Further investigation may be required in those cases with collection and culture of samples and antimicrobial susceptibility testing (AST), or using cytology and Gram staining at practice level. Samples for AST should be sent to accredited diagnostic laboratories, which follow standardised laboratory procedures such as those described by the Clinical and Laboratory Standards Institute (CLSI) (http://www.clsi.org) [36].

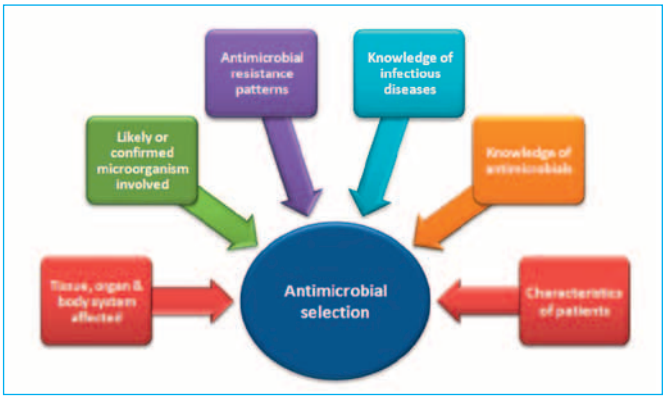

Fig. 2- Criteria considered for the selection of antimicrobials in small animal practice.

There is currently some discussion on the clinical value of the Minimum Inhibitory Concentration (MIC) used to define levels of resistance in ASTs. The MIC may not always be sufficient to determine if antimicrobial treatment will be effective and that clinical cure will occur. Consideration is now being given to new measurement units in conjunction with the MIC, such as the Mutant Prevention Concentration (MPC). The MPC takes into account the variation in antimicrobial susceptibility within high density bacterial populations and the likelihood of occurrence of less susceptible mutants in those same populations [37]. It is defined as the lowest concentration of antimicrobial necessary to inhibit the growth of the least susceptible organisms in highly dense bacterial populations [37]. The value of the MPC is consequently higher than that of the MIC. When such bacterial populations occur, antimicrobial dosage required for therapy should be based on the MPC, which may imply using higher dosages than those recommended by drug manufacturers or by current available scientific evidence. However, definition of standardised MPC measurements for different pathogens and antimicrobials is still ongoing and it may be some time before these are adopted by microbiology laboratories and applied routinely to veterinary isolates [37].

As such, ASTs remain the 'gold standard' test to investigate antimicrobial resistant patterns of animal pathogens in everyday small animal practice. Interpretation of culture and AST findings by veterinary surgeons in practice is often challenging. It is important that the practitioner interprets the laboratory tests in the clinical context, taking into account the clinical findings and animal patient to be treated.

Stewardship strategies

Stewardship of antimicrobials must be promoted at international, national and practice levels. In human medicine, antimicrobial stewardship programs are common in healthcare premises. Stewardship strategies include a) international and national awareness and educational campaigns for practitioners and general public, b) policies and guidelines at international, national and hospital/ practice levels, c) educational programs for medical, pharmacists and nurse staff, d) implementation of formularies and restrictions for antimicrobial use at hospital level, e) supervised/ revised prescription systems [30, 38].

General international guidelines and campaigns to promote the responsible use of antimicrobials can be used as a basis for the development of national guidelines taking into consideration common infectious conditions observed, licensed antimicrobial drugs and AMR patterns in each country. This will provide the veterinary surgeon with a tool in practice that can be used for the definition of protocols of antimicrobial usage in clinical and surgical cases.

a) Guidelines and campaigns at international level

Promotion of responsible use of antimicrobials in practice is one of the main aims of FECAVA's Working Group on Hygiene and Use of Antimicrobials in Practice. The Working Group aims to raise awareness in veterinarians of the occurrence of AMR and nosocomial infections in small animal practice and how to implement strategies that will prevent the occurrence of these infections. The Working Group will produce general recommendations for antimicrobial usage in therapy and prophylaxis of both clinical and surgical cases in the near future.

At European level, other associations are also involved in promoting responsible use of antimicrobials. The EPRUMA initiative (European Platform for the Responsible Use of Medicines in Animals) is involved in raising awareness for not only use of antimicrobials but also for antiparasitic drugs for which resistance is also an issue that can also compromise animal health. Stakeholders of EPRUMA include FECAVA, FVE (Federation of Veterinarians of Europe), IFAH (International Federation for Animal Health), amongst others. Its campaigns and recommendations are aimed at veterinarians, farmers and animal owners (http://www.epruma.eu/) [39].

In America, the ISCAID (International Society for Companion Animals Infectious Diseases) is currently developing guidelines for antimicrobial therapy of common conditions in dogs and cats. This guidelines will be published in due time by ISCAID (http://www.iscaid.org/) [40].

Often international guidelines and campaigns cannot represent or cover all the aspects and differences observed between countries in the care of companion animals and the prevalence of infectious diseases. Nonetheless, international guidelines and campaigns are important as these define a general framework of recommendations for national associations and veterinarians to support their decision-making process when selecting antimicrobial therapy.

b) Guidelines and interventions at national level

Development of guidelines in each country should take into account the prevalence of infectious diseases, the patterns of AMR and the extent of antimicrobial usage in small animal populations. Guidelines for antimicrobial usage will not be effective if these are not considered, as each country is different in its own way. Major differences may be observed in terms of licensed antimicrobials available for veterinary use, legislation, prevalence of common infectious diseases affecting small animals and levels and patterns of AMR in animal pathogens. As such, guidelines of a specific country cannot and should not be adopted by other countries without previous assessment of

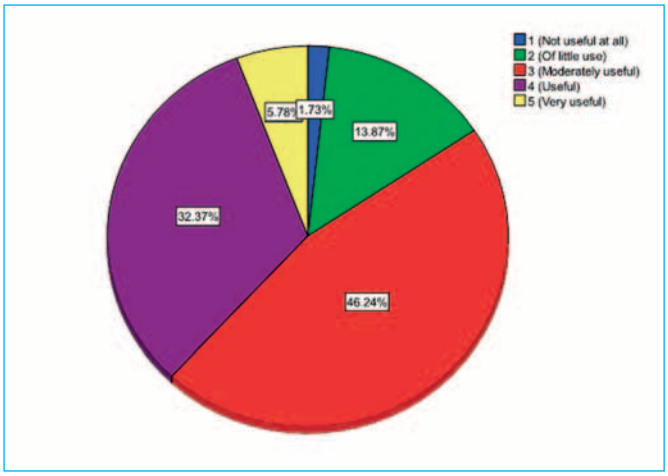

Fig. 3 Perceived usefulness of current guidelines for antimicrobial usage by small animal veterinarians in the UK

Fig 4 Implementation of antimicrobial stewardship in practice (Adapted from Fishman, 2006, AJIC with authorisation of the author and the publisher).

how the situation observed in veterinary practice and animal populations differ between those countries. It is only when these guidelines have been adapted to the specific conditions observed in the country of interest that they will be effective in changing antimicrobial usage patterns in small animal practice.

Restrictions on the use of certain antimicrobials in veterinary practice may be imposed on veterinary practitioners in the near future. Recently in the UK there was a recommendation from the Chief Medical Officer, Sir Liam Donaldson to ban the use of fluoroquinolones and cephalosporins in animals due to the perceived risk of resistance to these antimicrobials in human pathogens [41]. It is thus vital that the veterinary profession promotes and uses antimicrobials responsibly and is aware of hygiene protocols and infection control measures at practice level to control the emergence and spread of AMR pathogens and determinants.

In a recent survey by FECAVA amongst its member states (n=36), only 4 countries possessed national guidelines for antimicrobial usage in companion animals. These were the UK, Norway, Sweden and Netherlands. Formats of guidelines varied from general principles of antimicrobial usage (i.e. "use narrow-spectrum antimicrobials whenever possible") to specific approaches recommended for individual common bacterial clinical conditions in small animals, as observed in the UK and in Sweden, respectively [42, 43]. In a recent FECAVA survey of members of the British Small Animal Veterinary Association (BSAVA), over 80% of the veterinarians questioned about the usefulness of current guidelines for use of antimicrobials found them to be useful or moderately useful for everyday practice (Fig 3). The extensive lack of national guidelines throughout Europe is alarming, as guidelines are important to promote responsible use of antimicrobials and raise awareness of the risk of AMR in companion animals. National guidelines will provide the framework for veterinarians to adapt appropriate protocols and policies to their own workplace. Furthermore, veterinary faculties should integrate teaching focused on evidence-based medicine, provide a relevant undergraduate training in antimicrobial and infectious diseases knowledge and raise awareness of AMR in small animal practice. National veterinary associations must become more active and support and inform their members of the promotion of rational use of antimicrobials in everyday practice. These associations should also promote further training of veterinarians in antimicrobial usage, knowledge of infectious diseases, hygiene and infection control in practice.

c) Guidelines and protocols at practice level

Antimicrobials protocols should be implemented for therapy of bacterial conditions commonly observed in practice. This would include clinical conditions such as pyoderma or urinary tract infections (UTIs) in dogs and conjunctivitis or rhinitis in cats. Protocols for the management of traumatic wounds and abscesses particularly in cats should be defined, as these often do not require systemic antimicrobial therapy [44].

'Prophylactic' use of antimicrobials in surgical cases must be controlled at practice level. Current recommendations in the UK state that no antimicrobials should be used for 'prophylaxis of infection' in surgical cases where proper theatre hygiene, surgical asepsis and good surgical techniques have been observed [42]. This is to reduce the unnecessary prophylactic use of antimicrobials in small animal practice. Antimicrobials should not be used as a substitute for good hygiene in practice. They should only be considered when there is evidence of a significant risk of bacterial infection, either because of the long duration of the surgery, poor surgical technique or where there is potential contamination of the surgical wound.

A recent FECAVA survey of members of the British Small Animal Veterinary Association (BSAVA) revealed that only 48% of the participants (n=296) worked in veterinary practices with established protocols for antimicrobial usage. Of those, 36% had protocols for surgical prophylaxis, 15.0% had protocols for therapy of resistant infections (i.e. MRSA), and routine clinical cases but only 8.1% had protocols for therapy of immune-suppressed animals (multiple answers were allowed).

Antimicrobial usage protocols in practice can include categories for use of antimicrobials for common clinical infectious conditions, so that antimicrobials can be separated into those

Key points of hygiene infection control

- Hand hygiene
- Cleaning & disinfection of premises
- Use of protective clothing
- Use of gloves
- Training of staff
- Education of pet owners
- Management of clinical waste
- Laundering of clothing and bedding materials

Table 2- Summary of the recommendations for hygiene and infection control in companion animal practice.

to be used empirically (without AST but less likely to originate AMR) and those antimicrobials that are only indicated when supported by AST results (Table 1) [33, 45].

Strategies for the control of antimicrobial resistance (AMR) and nosocomial infections in practice in conjunction with antimicrobial stewardship

a) Hygiene and infection control

Hygiene is an important component of infection control measures in practice (Fig. 4). It has an important role in the containment and eradication of infectious agents in the workplace. Hygiene protocols are essential to contain the spread of nosocomial infections in human healthcare settings. Hand washing and disinfection has been proved to be effective in containing the spread of MRSA in healthcare professionals, their patients and the environment [46]. Transfer of MRSA in veterinary practice can occur in any direction between staff, animals and pet owners [2, 47]. Transmission of MRSA has also been observed between pet owners and their animals and vice-versa at household level [2]. In veterinary practice, it has also been observed that surfaces such as door handles and computer keyboards and telephones can be contaminated with MRSA and other pathogens [48, 49]. Cleaning and disinfection of equipment and facilities with approved products can prevent the occurrence and transmission of nosocomial infections in veterinary settings. Hygiene protocols in practice are therefore important to reduce the burden of infection at practice level and help to reduce the unnecessary use of antimicrobials in companion animals.

Infection control in practice is essential, regardless of the size of the practice. Nosocomial infections are becoming more common in veterinary practices [50]. Pathogens involved are often resistant to antimicrobials and also have zoonotic potential [23, 51]. Control measures will probably vary according size of practice, veterinary services provided and nature of clinical and surgical cases involved. Nonetheless, even small veterinary practices should have basic infection control measures when dealing with infectious diseases. This will involve having written protocols that will provide clear instructions to veterinary staff.

Recently, the Working Group has developed a poster with recommendations for hygiene and infection control measures in practice (http://www.fecava.org/files/952.pdf) [52]. An earlier

Table 1 Example of classification of antimicrobials according to priority of use in companion animal practice [1, 2] (Permission for use obtained from Scott Weese the author of the table).

Category	Definition	Examples
First line	• Initial empirical therapy with known or suspected bacterial infections • Prior to culture and antimicrobial sensitivity tests • Antimicrobials are considered less important in human medicine for the therapy of infectious conditions • Antimicrobials less likely to induce or spread antimicrobial resistance in human pathogens and commensal bacteria	• Penicillin • 1st and 2nd generation cephalosporins • Trimethoprim-sulfonamides
Second line	• Antimicrobials used only when supported by results from culture and antimicrobial sensitivity tests • Animal and infection factors determine that first line antimicrobials are inadequate for therapy • Classified as critically important in human medicine for the therapy of life-threatening conditions • Antimicrobials may give origin to antimicrobial resistance	• Fluoroquinolones • 3rd and later generation cephalosporins
Third line	• To be used in life-threatening conditions but only supported by results of culture and antimicrobial sensitivity tests • To be used when 1st and 2nd line antimicrobials are not indicated • Classified as critically important in human medicine for the therapy of life-threatening conditions • Loss of efficacy and AMR to this antimicrobial has serious implications for human health	• Carbapenems
Last resort (can be restricted for use in practice)	• To be used in life-threatening conditions but only supported by results of culture and antimicrobial sensitivity tests when there aren't any other therapeutic options available • Classified as critically important in human medicine for the therapy of life-threatening conditions • Loss of efficacy and AMR to this antimicrobial has serious implications for human health	• Vancomycin

version of this poster was presented at the Annual Conference of WSAVA in June 2010, during the "One Health" Symposium [52]. A brief summary of the key recommendations can be found in Table 2. The Working Group recommends that every veterinary practice should display this poster in their veterinary staff common area. These recommendations will act as a reminder and raise awareness of best practice to be followed by veterinary staff at all times to prevent and control nosocomial infections in the workplace.

b) Preventive Medicine protocols

Vaccination and worming programs are important in the prevention of both infectious and parasitic diseases, respectively and play an important role in everyday practice. These help to reduce the burden of disease in populations and consequently, the need for antimicrobials is also reduced [30]. Promotion of health plan packages in veterinary practices to pet owners is becoming more common. Vaccination programs should be based on sound scientific evidence for the country of interest and follow current recommendations, as, for example, those published recently by the Working Vaccination Guidelines Group of the WSAVA [53].

Vaccination programs also have an important role in promoting awareness of pet owners of the risk of infectious diseases and their responsibility for the protection of their pets. Furthermore, consultations for vaccination purposes should include a full clinical examination of the animal. This will allow the veterinarian to monitor the health status of the animal regularly and not only when the animal is sick [33].

c) Improvement of diagnostic tools in practice

Diagnostic tools are very important in everyday practice and are often vital to obtaining confirmation of the clinical diagnosis. Culture and antimicrobial susceptibility tests are often used for investigation of infectious agents and AMR pathogens in small animal practice [54]. Careful interpretation of AST findings in the clinical context is required. Microbiological reports can refer to the isolation of non-pathogenic bacteria and its antimicrobial susceptibility patterns and using that advice may lead to misuse of antimicrobials by the veterinarian. Although ASTs are very important diagnostic tools in bacterial infections, interpretation of results requires background knowledge of potential pathogens and antimicrobials.

There are exceptions when pet owners are not willing or able to pay for ASTs or for other diagnostic tests deemed necessary by the veterinarian in order to obtain a final diagnosis [33]. In these particular cases, veterinarians can use in-house tests that may help to direct them, if not to a confirmed diagnosis, then at least to a presumptive diagnosis. Bacterial slides using quick-staining techniques (i.e. Diff-Quik, Gram staining) may help to narrow the selection of antimicrobials by veterinarians when assessing the type of bacteria (i.e. rods, bacilli, cocci) isolated and the reaction to colouration (Gram negatives versus Gram positive) [54]. However, it is important to remember that these tests do not provide information of acquired resistance patterns as ASTs do. Furthermore, as the organism is not fully identified, the veterinarian cannot be certain that it is pathogenic. In contrast, quick-staining tests are often less expensive and faster than ASTs. The type of equipment needed for microbiology can be easily acquired even in small sized practices and can be very useful to help in the decision-making process involved in the selection of antimicrobials for animal therapy.

d) Development of new antimicrobials and vaccines

Antimicrobial research and development by pharmaceutical companies has slowed down in the last couple of decades [55]. There is growing concern about the uncertainty associated with the production of new antimicrobials and whether new antimicrobials will be effective to treat infections caused by multi-resistant pathogens. This is mainly due to the high cost and length of time involved in research and development of antimicrobials, particularly relating to clinical trials [56].

In contrast, development of vaccines is a growing market in both human and veterinary fields. In human medicine, research is being directed to the development of vaccines against susceptible bacteria (e.g. *Staphylococcus aureus*), as these have been shown to reduce the burden of disease and the incidence of infections with resistant-strains [57]. Recent studies have shown that vaccine development against MRSA would be cost-effective for the control of this pathogen in populations at risk (e.g. neonates) [58]. In veterinary medicine, there is scope for the research of vaccines to prevent common bacterial diseases [59]. New vaccines in companion animals would protect susceptible populations, reduce the burden of disease and prevent the spread of infection. Consequently, the use of antimicrobials in small animal populations would be reduced.

e) Promoting responsible use of antimicrobials in practice

Training and education of veterinary staff is important at practice level to improve antimicrobial prescription behaviour and raise awareness of the risks to public health. Education of pet owners is also a vital part of the process. Good communications skills are vital to establish a relationship of trust with the pet owner and can improve compliance to prescribed therapies. Veterinarians should also use communication to raise awareness and educate clients concerning AMR issues in small animals [60]. Motivation and involvement of pet owners in the therapy of their animal is therefore important to achieve and improve compliance to prescribed therapy. "Involvement" means that after antimicrobial selection, the veterinarian should check with the pet owner on his/ her willingness or ability to administer the therapy and explain thoroughly the regimen prescribed. Written labels of prescribed therapies should include clear instructions to pet owners for drug delivery. Compliance of pet owners often decreases with long antimicrobial therapies (e.g. deep pyoderma) and with increased frequency of dosing in antimicrobial regimens [61]. Clients must be made aware of the importance of administering antimicrobials correctly and of finishing therapeutic courses.

Effectiveness of stewardship programs

Antimicrobial stewardship programs should be constructed with the aim of achieving specific targets. Programs should aim to reduce the usage of antimicrobials that have a known impact

on the occurrence of AMR in specific animal pathogens and should aim to reduce the incidence of nosocomial infections (e.g. MRSA, *Clostridium difficile*) in practice [33]. Stewardship programs that are too unspecific or too vague may be ineffective or even prejudicial, if selective AMR occurs as a consequence of the programme itself [30, 33]. Furthermore, stewardship programs should be implemented only if hygiene and infection control measures are also in place, in order to optimise results, as described above. In human medicine, stewardship programs are common and their efficacy is well documented. A recent review by MacDougall and Polk in human medicine showed that often antimicrobial stewardship programmes combine multiple strategies. As such, assessment of efficacy of stewardship programmes is often challenging due to their complexity [38]. Healthcare systems that include committed management and senior staff and available resources to support development of stewardship programmes are essential for an efficient programme. Furthermore, active involvement of staff (i.e. pharmacists, clinicians, surgeons, nurses), in the development of stewardship programmes has been shown to improve adherence by providing a sense of ownership [38]. Policies for antimicrobial usage which include restrictions of use of certain antimicrobials have also proven effective. However, these may raise concern due to the loss of clinical freedom associated with the act of prescribing. Review of prescriptions and provision of feedback by clinical pharmacists and specialists in infectious diseases to prescribers were effective and were not perceived to compromise clinical freedom [38]. From all stewardship programmes evaluated by MacDougall and Polk, those found to be least effective were guidelines for responsible use of antimicrobials ('passive education of prescribers') and cycling (i.e. rotation), of antimicrobials [38].

In veterinary medicine, evidence of efficacy of stewardship programs is scarce. Recently, Scott Weese described a study assessing the efficacy of implementation of guidelines stating categories for antimicrobial use in a veterinary teaching small animal hospital [62]. The objective of the program was to reduce usage of fluoroquinolones and imipenem. The study assessed antimicrobial usage before and after implementation of the guidelines (n=9 years). A decrease overall in the number of antimicrobial prescriptions, as well as a decrease in the usage of fluoroquinolones was observed after the implementation of the guidelines [62].

Conclusions

Antimicrobials are very important tools for everyday work in companion animal practice. Misuse of antimicrobials in both human and veterinary practice can lead to the loss of efficacy of these drugs in the long term and could have serious consequences for both animal and public health. However, there is currently lack of baseline surveillance data to determine the extent and patterns of antimicrobial consumption and AMR trends in companion animal populations. As such, it is difficult to evaluate the role of companion animals in the epidemiology of AMR and to develop informed guidelines and protocols for responsible use of antimicrobials in everyday practice. Promotion of responsible use in companion animal practice is important to prevent the occurrence of AMR and the spread of nosocomial infections with resistant organisms. Antimicrobial stewardship programs should be implemented in conjunction with infection control and hygiene measures in veterinary practices, regardless of the size of practice involved.

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Recognising and controlling risk factors for antimicrobial resistance

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SUMMARY

Antimicrobial resistance amongst organisms such as *Escherichia coli*, *Pseudomonas aeruginosa*, methicillin-resistant *Staphylococcus aureus* (MRSA) and *S. pseudintermedius* has become a serious threat to veterinary small animal practice. There is an urgent need to adopt measures which will control and reduce this problem. Risk factors for infection by resistant organisms in small animals are now becoming recognised and appear to mirror those in human medicine. They include contact with carriers or infected animals, hospital admission, invasive procedures and antimicrobial therapy. Key recommendations which enable such risk factors to be avoided are: development of protocols which ensure that antimicrobials are used only when necessary, selection of appropriate antimicrobials and compliance with correct dosage and administration, limitation of prophylactic and perioperative use, and recording of treatment outcomes so that therapeutic regimens can be evaluated and modified if necessary. In addition, there is a need for rigorous hygiene protocols to prevent survival and transfer of resistant bacteria in clinics and hospitals.
Key words: Risk factors, antimicrobials, therapy, resistance, hygiene,

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Introduction

The problem of increasing antimicrobial resistance is now clearly recognised throughout the world not only in human and veterinary medicine but also in related industries such as agriculture and aquaculture [Gould, 2009]. This is a consequence of misuse of antimicrobial agents leading to the selection of multiresistant bacteria.

Although the issue of multiresistance was first highlighted and publicised in the human field and agricultural use of antimicrobial agents as growth promoters was incriminated as a contributor, the role of small animal practice is becoming more apparent [Guardabassi *et al*, 2004]. Infections with strains of multi-resistant bacteria that are difficult to treat, such as *Escherichia coli* and *Pseudomonas aeruginosa* are now commonly encountered in dogs and cats, and methicillin-resistant *Staphylococcus aureus* (MRSA) infections are increasingly recognised. Outbreaks of infection with highly resistant strains of *Acinetobacter baumannii* are also being reported [Boerlin, 2001]. Worryingly, the common staphylococcal species associated with infections in dogs and cats, *S. pseudintermedius* [formerly *S. intermedius*; Sasaki *et al*, 2007] has now developed increased capacity for multiresistance, including acquisition of the mecA gene, giving resistance to all beta-lactam antibiotics. This methicillin-resistant *S. pseudintermedius* (MRSP) now has a worldwide distribution with high prevalence in certain countries and rapid spread in Europe since first described in Germany [Loeffler *et al*, 2007].
The consequences of the rise in frequency of these multiresistant bacteria in veterinary practice go beyond clinical difficulties experienced in treating cases successfully. These bacteria can cause zoonotic infections and act as a source of resistance genes for organisms associated with human infection. Alarm has been raised in the human field with the suggestion that certain agents should be withdrawn from veterinary use. Indeed, the English Chief Medical Officer has suggested that quinolones and cephalosporins should be banned from animal use [Donaldson, 2008]. Veterinary clinicians need to respond to these threats by more careful use of antimicrobials. This review summarises risk factors which can lead to the development of antimicrobial resistance and identifies measures which can be taken to reduce their significance in small animal practice.

Antimicrobial resistance risk factors

Risk factor analysis in relation to antimicrobial resistance requires systematic identification and assessment of factors that influence the probability and consequences of its development. Although there is a lack of such systematic studies both in human medicine and small animal medicine [Lloyd, 2007; Carmeli, 2008], there is agreement on the principal bacterial pathogens causing concern.

These include the pathogenic staphylococci and particularly *S. aureus, Enterococcus* spp., members of the Enterobacteriaceae, especially *E. coli*, and *Ps. aeruginosa*, organisms which share risk factors promoting nosocomial colonization and infection [Sadfar and Maki, 2002]. These bacteria can be carried by diseased and healthy individuals and may persist for long periods in hospitals and other healthcare institutions, and in domestic environments. The hospital or clinic environment is particularly suited to their survival and transmission; there is a continual supply of susceptible patients receiving antimicrobials to which the bacteria may be resistant and patients can thus be colonized or infected and cause further contamination.

Sadfar and Maki [2002] reviewed evidence of risk factors for such organisms in a total of 74 studies in human medicine and demonstrated that advanced age; underlying diseases and severity of illness; inter-institutional transfer of the patient; prolonged hospitalization; gastrointestinal surgery or transplantation; exposure to invasive devices , especially central venous catheters; and exposure both individually and to combinations of narrow and broad spectrum antimicrobials were involved. Such studies are lacking in the veterinary field but there is evidence from publications on MRSA infection which indicates that risk factors for dogs and cats mirror those in the human field and include carriage of MRSA, contact with carriers, duration of hospital admission and invasive procedures [Lloyd *et al* 2007; Loeffler and Lloyd, 2010]. In the USA, [Black *et al* 2009] showed that amongst 74 dogs in an intensive care unit, multidrug-resistant patterns occurred in 27% of all isolates and were more likely to occur in organisms cultured after 48 hours of hospitalisation. Veterinary staff members and owners are at increased risk of becoming carriers of such nosocomial organisms when they are in contact with infected animals [Loeffler and Lloyd, 2010]. Indeed studies in animal hospitals have shown that staff MRSA carrier rates as high as 27% can occur [Baptisite *et al*., 2005].

Strategies for avoidance of risk factors

There is now an impetus in many countries to define measures which can be taken to use antimicrobial agents in animals in responsible ways and reduce levels of resistance [Prescott 2008]. Guidelines are being created at different levels of complexity varying from general concepts to specific recommendations for individual disease conditions and specific infective organisms. An example of the latter is the article on dealing with MRSA in small animal practice [Lloyd *et al* 2007] commissioned by FECAVA (The Federation of European Companion Animal Veterinary Associations) which has established a Working Group on Hygiene and the Use of Antimicrobials in Veterinary Practice to bring together and co-ordinate recommendations within small animal practice in Europe [Lloyd *et al*, 2009].

In the UK, both the British Veterinary Association and the British Small Animal Veterinary Association have published recommendations on prudent use of antimicrobials on their websites [see BVA, 2009; BSAVA 2009]. The BVA has produced a downloadable poster suitable for display which lists an 8 point plan (summarized in Table 1) providing actions and advice suitable for veterinary practice. The key points are a) development of protocols which ensure that antimicrobials are used only when necessary, b) selection of appropriate antimicrobials following sensitivity tests if possible, and compliance with correct dosage and administration, c) limitation of prophylactic and

Table 1. Summary of the British Veterinary Association 8-Point Plan for Responsible Use of Antimicrobials (BVA, 2009).

The 8 Points	Details and Comments
1. Work with clients to avoid need for antimicrobials	Adopt integrated disease control programmes. Isolate infected animals wherever possible.
2. Avoid inappropriate use	Restrict to ill or at risk animals. Advise clients on correct administration and the need for completion. Avoid underdosing.
3. Choose the right drug for the right bug	Identify likely target organisms and their susceptibility. Create practice-based protocols for common infections based on clinical judgement and up-to-date knowledge. Know how antimicrobials work and their pharmacodynamic properties. Use antimicrobials with a spectrum as narrow as possible.
4. Monitor antimicrobial sensitivity	While clinical diagnosis is often the initial basis of treatment, microbial sensitivity must be determined whenever possible so that modified treatment can be implemented if necessary.
5. Minimise prophylactics use	Only when animals are at risk and usage indicates reduced morbidity and or mortality. Regularly assess prophylactic use. Develop written protocols for when prophylactic medication is considered appropriate. Monitor antimicrobial sensitivity trends.
6. Minimise use perioperatively	Use only when necessary and supported by strict aseptic techniques alongside written practice guidelines.
7. Record and justify deviations from protocols	Be able to justify your choice of antimicrobial and dose. Record treatment and outcome to help evaluate therapeutic regimens.
8. Report suspected failure to VMD*	This may be the first indication of resistance. Report through the Suspected Adverse Reaction Surveillance Scheme of the VMD.

*UK Veterinary Medicines Directorate

Drug Class	When Used	Drug Examples
First-line	Initial treatment of known or suspected bacterial infection in absence of susceptibility results. These drugs may commonly be used in human medicine but are usually considered less important for treating serious human (and animal) infections or raise less concern about development of resistance.	Penicillin, most cephalosporins, trimethoprim-sulphonamides, tetracyclines
Second-line	Used when culture and susceptibility testing, plus patient or infection factors, indicate that no first-line drugs are reasonable choices. Drugs in this class may be more important for treatment of serious human (and animal) infections or there may be particular concern about development of infection.	Fluoroquinolones, 3rd and later generation cephalosporins
Third-line	Used in serious, life-threatening infections, with support of culture and susceptibility results, when no first-line or second-line drugs are indicated.	Carbapenems
Restricted	Used only in life-threatening infections when culture and susceptibility testing indicates no other options.	Vancomycin

Table 2. Strategic use of antibacterials in animals (after Weese, 2006)

perioperative use, and d) maintenance of records of treatment outcomes so that therapeutic regimens can be evaluated and modified if necessary.

Selection of appropriate drugs and their correct use is, of course, of vital importance. When treatment must be instituted rapidly or there is a high level of confidence that the causative organism and its sensitivity can be predicted, appropriate "first line" drugs can be selected (Table 2). Otherwise, sensitivity tests should be carried out and "second line" drugs may be required. An important component of this process is client education conveying the dual message that both avoidance of non-essential antimicrobial administration and full compliance with dosage regimens of prescribed courses of antimicrobial drugs reduce the risk of increasing bacterial resistance.

To this list must be added the need for rigorous hygiene so that as resistant organisms are encountered, in infected animals or in healthy carriers, transmission to other patients or humans is prevented. This applies not only to hospital facilities, where barrier nursing or isolation needs to be applied if there is a risk of carriage, but also in the clinic where protective clothing should be worn and replaced after handling animals known or suspected to carry resistant bacteria and where surfaces touched by patients should be disinfected before admission to the consulting room of the next animal.

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Methicillin-resistant staphylococcal infections in pets

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INTRODUCTION

The *Staphylococcus* genus contains a diverse group of species that are common commensals of the skin and mucous membranes of humans and an impressive range of animal species. While commonly found in or on healthy individuals, they are also important causes of opportunistic infections. The clinical relevance of different *Staphylococcus* species is quite variable, with some being important causes of infection and others minimally pathogenic.

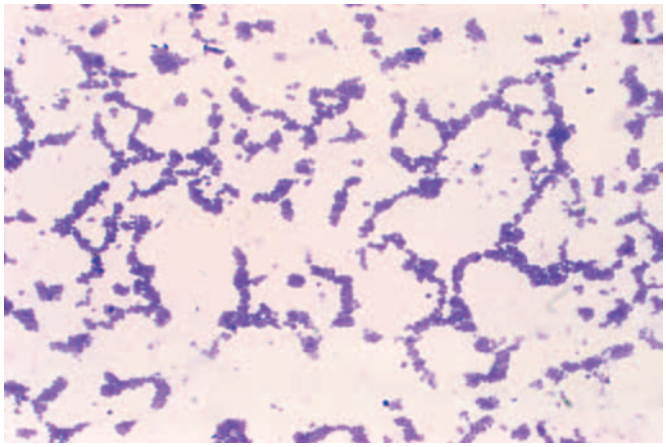
All staphylococci are Gram positive cocci (Figure 1) and can be divided into 2 groups, based on their production of the enzyme coagulase (Table 1). Coagulase positive staphylococci are the most important clinically. In dogs and cats, *S. pseudintermedius, S. aureus* and *S. schleiferi* subsp *coagulans* are the main coagulase positive species and main staphylococcal pathogens. Previously, *S. intermedius* was considered the most important *Staphylococcus* in dogs and cats, but it is now known that what was previously identified as *S. intermedius* is truly the closely related species *S. pseudintermedius* [1, 2], and *S. intermedius* is actually rare to non-existent in dogs and cats. Previously published reports of *S. intermedius* almost certainly actually involved *S. pseudintermedius*, and for the purposes of this review, older studies reporting *S. intermedius* are considered to be *S. pseudintermedius*.

Coagulase negative staphylococci (CoNS) are common commensals that can cause disease but are more often found as skin contaminants. In general, they are considered minimally pathogenic, however certain CoNS might be more pathogenic, particularly *S. schleiferi* subsp *schleiferi* in pyoderma and otitis externa and *S. felis* in urinary tract infections.

Pathophysiology

Staphylococci can possess an impressive array of virulence factors, and the role of these in development of disease is variable (and often poorly understood). Some virulence factors facilitate adhesion to host tissues (adhesins, clumping factors, fibronectin binding proteins, collagen binding protein, coagulase), some facilitate immune invasion (*S. aureus* protein A), while some encode secreted enzymes and toxins (haemolysins, hyaluronidase, hyaluronate lysate, lipase, leukocidins, enterotoxins, exfoliative toxin, toxic shock syndrome toxin). Some staphylococci are able to form biofilms; extracellular polysaccharide networks that help the bacteria evade the effects of antimicrobials and the immune system. The role of specific virulence factors in disease is poorly understood, and there are currently no virulence factors that can be used as important markers of clinical virulence in companion animals.

Figure 1: Gram stain of Staphylococcus aureus. Note the Gram positive (purple) appearance and the tendency of cells to form clusters (Public domain, photo credit Dr. Richard Facklam, Centers for Disease Control and Prevention).



Coagulase positive species	Coagulase negative species
S. aureus *S. intermedius* *S. pseudintermedius* *S. schleiferi subsp coagulans* *S. delphini*	*S. epidermidis* *S. haemolyticus* *S. schleifer subsp schleiferi* *S. warneri* *S. xylosus* *S. hominis*

Table 1: Examples of coagulase positive and coagulase negative staphylococci.

Methicillin-resistance

From the first introduction of antimicrobials, staphylococci have demonstrated an impressive ability to develop antimicrobial resistance. Penicillin-resistance was identified shortly after penicillin became widely used. Early in the 'antibiotic era', the obvious approach to overcoming clinical problems with penicillin-resistant staphylococci was development of new antimicrobials. New drug development outpaced resistance initially, but the ability of staphylococci to become resistant was repeatedly demonstrated as the introduction of new drugs was typically followed shortly by identification of resistant strains. Included in this pattern was resistance to methicillin. This penicillinase-resistant penicillin was released in humans in 1959, and the first report of methicillin-resistant *S. aureus* (MRSA), was published in 1961. Unlike penicillin-resistance, which was caused by secretion of beta-lactamase, methicillin-resistance was caused by production of an altered penicillin binding protein (PBP) [3]. Penicillin binding proteins are parts of the normal cell wall, and they are also the site of beta-lactam antimicrobial attachment. The abnormal PBP in MRSA (called PBP2a or PBP2`) has a poor affinity for beta-lactam antimicrobials and confers resistance not just to methicillin, but to virtually all beta-lactams; penicillins, cephalosporins and carbapenems. Production of PBP2a is mediated by the *mecA* gene, a gene that is located on a staphylococcal chromosomal cassette (SCC*mec*) [3]. This site also has the ability to acquire other resistance genes, and methicillin-resistant staphylococci are often resistant to a wide range of other antimicrobials.

While the evolution of methicillin-resistance has been best studied in MRSA, the same mechanism is present in all methicillin-resistant staphylococci. Methicillin-resistant staphylococci, particularly MRSA and methicillin-resistant *S. pseudintermedius* (MRSP) are emerging as serious problems in veterinary medicine.

Methicillin-resistant *Staphylococcus pseudintermedius* (MRSP)

Epidemiology

MRSP has rapidly emerged as a critically important problem in companion animal practice. This organism appears to have emerged and disseminated internationally at a truly amazing rate, with rapid development of a very high level of drug resistance. MRSP infections are being identified virtually everywhere that people are looking, and the increase in incidence of disease, while not objectively studied, seems to be great. It has been called a serious emerging problem in small animal veterinary medicine and one that requires urgent action to control its spread [4].

To understand MRSP, it is critical to understand *S. pseudintermedius*. *Staphylococcus pseudintermedius* is the most common pathogenic *Staphylococcus* in dogs. It is also a common commensal and can be found in or on 31-68% of healthy dogs [5-8]. Higher rates (up to 100%) have been reported in puppies [9]. It is quite possible that colonization (also often termed 'carriage') is ubiquitous in dogs, and that *S. pseudintermedius* could be found on almost all dogs if one looked hard enough. Various body sites can be colonized, particularly the nasal passages, oral cavity, skin and perineal mucosa [5, 7]. While *S. pseudintermedius* is very common in healthy dogs, it is also a leading cause of infection, ranging from mild and superficial to fatal invasive infections. As with many opportunistic pathogens, certain predisposing factors are known or suspected to be associated with an increased risk of disease (e.g. atopy, flea allergy, surgery, immunocompromise), but infections can occur in the absence of any recognizable risk factor.

This bacterium is less common in cats, being reported in 6.8-22% of healthy cats [8, 10-12]. It is unclear whether this bacterium is truly adapted to cats as a commensal or whether it periodically and transiently colonizes or infects susceptible individuals. As with dogs, opportunistic infections can develop but *S. pseudintermedius* infections are less common in cats compared to dogs [13].

As with methicillin-susceptible strains, MRSP can be found in or on healthy dogs and cats. Carriage rates of 0-17% in dogs and 0-1.2% in healthy cats have been reported [6, 8, 14-16], and it appears that the rate of colonization is increasing in many regions. Risk factors for MRSP colonization have not been adequately investigated.

As with susceptible staphylococci, MRSP is an opportunistic pathogen and colonization does not necessarily lead to disease. Indeed, it is likely that the vast majority of colonized animals never develop a clinical infection. The risk of infection in MRSP carriers has not been reported, but it is reasonable to assume that MRSP carriers are at some increased risk of MRSP infection, at least in certain situations (e.g. after surgery). Limited study of risk factors for infection has been performed but antimicrobial administration, hospitalization or surgery within 30 days prior to the onset of infection were associated with MRSP versus methicillin-susceptible *S. pseudintermedius* infection in one study [17].

Clinical presentation

Staphylococcus pseudintermedius accounts for the vast majority of cases of pyoderma in dogs, and a lesser percentage in cats. It also causes a range of other infections including wound infections, surgical site infections, septic arthritis, osteomyelitis, urinary tract infections, endocarditis, liver abscess, peritonitis and ocular infections. As with other opportunistic pathogens, the spectrum of disease can range from mild to fatal, although fatal infections are rare. Fatal toxic shock and cellulitis [18] and necrotizing fasciitis [19] have been reported.

Methicillin-resistant *S. pseudintermedius* causes the same spectrum of disease, with a predominance of skin, ear and

other soft tissue infections [17, 20-22]. Post-operative infections appear to be increasingly common, particularly TPLO infections [17]. There is no indication that MRSP infections are more serious than infections caused by methicillin-susceptible strains, however they may be more difficult to treat.

Methicillin-resistant *Staphylococcus aureus* (MRSA)

Epidemiology

As with MRSP, an understanding of MRSA requires basic knowledge of *S. aureus*. *Staphylococcus aureus* can be isolated from the nares, perineum or intestinal tract of 12-14% of healthy dogs and 4.3-20% of healthy cats [6, 8, 10]. Whether it is truly a canine and feline commensal, or whether isolation of *S. aureus* is the result of short-term acquisition of the bacterium from human sources is unclear. In a study of dogs and their owners, in 50% of households where *S. aureus* was isolated from both a dog and family member, the *S. aureus* strains were indistinguishable, strongly suggesting interspecies transmission, and likely from humans to animals [8]. Regardless, it does not particularly matter whether *S. aureus* is a true commensal or common short-term colonizer from human contact since the bacterium can clearly be isolated from a small percentage of healthy dogs and cats, and can cause opportunistic infections.

Emergence of MRSA in companion animals is probably a direct reflection of changes in the prevalence of MRSA in people in the general population. Specifically, the emergence of community-associated MRSA in humans in the 1990s and 2000s, with increasing numbers of human MRSA carriers in households resulted in potential exposure of large numbers of pets to MRSA. It is quite clear that MRSA in companion animals is intimately linked to MRSA in humans, was probably a key event in the emergence (or spillover) of MRSA into companion animals. Humans are thought to be the source of infection for a large percentage, if not the vast majority, of infections in pets, and changes in the epidemiology of MRSA in humans can be reflected in changes in trends in pets.

First reported in the 1990s, MRSA infection and colonization have now been identified in dogs, cats and other companion animals across the world [23-29]. As with *S. aureus,* MRSA can be found in healthy animals, particularly in the nasal passages, intestinal tract and perineum. Reported colonization rates are variable but tend to be 0-3.3% in healthy dogs and 0-6% in healthy cats [10, 30-34]. Higher rates can be encountered periodically in animals in veterinary facilities [25, 35], and being presented for veterinary treatment was a risk factor for colonization in one study [32]. However, most MRSA cases are not associated with veterinary hospitals. Higher rates can also be found in specific dog populations such as households where another pet has an MRSA infection [36], or during outbreaks in breeding or rescue kennels [37, 38]. Being owned by a human healthcare worker and participation in hospital visitation programs have been identified as risk factors for MRSA colonization in dogs, and are logical based on the increased likelihood of exposure to colonized people [24, 39]. Contact with children has also been identified as a risk factor [39]. While these, and potentially other, risk factors should be considered, MRSA can be identified in any animal and absence of known risk factors should not lead to excluding MRSA from consideration.

Most animals that are colonized with MRSA have no signs of infection and may never develop a clinical infection. In humans and horses, MRSA colonization is known to be a risk factor for clinical MRSA infection in certain circumstances (e.g. after admission to hospital) [40, 41]. It is reasonable to assume that this also applies to dogs and cats yet this is not proven.

The hypothesis that MRSA in companion animals is intimately linked to MRSA in humans is supported by the recurring observation that MRSA strains found in companion animals are predominantly the most common human strains in any given region [24, 28, 31, 39, 42-44]. Virtually all MRSA isolates from pets are recognized human epidemic clones and identification of other strains in dogs and cats is rare [28, 37, 39, 44, 45]. Sequence type 398 MRSA, a livestock-associated strain, has been found in a limited number of dogs [38, 46, 47], however dogs were more likely infected by people that were exposed to livestock.

Clinical Presentation

S. aureus produces a similar range of disease as *S. pseudintermedius*. The main difference between *S. pseudintermedius* and *S. aureus* is the incidence of disease, not disease location or severity. *Staphylococcus aureus* infections may be more common in cats compared to dogs.

Clinically, MRSA infections are indistinguishable from those caused by MSSA (methicillin resistant *S. areus)*, predominantly skin and ear infections, with smaller numbers of other opportunistic infections [6, 13, 28, 44, 45, 48-51]. It is possible that infections more commonly associated with human-contact (e.g. wound and surgical site infections contaminated by hands of owners or veterinary personnel) are more likely to be caused by *S. aureus* (including MRSA) but objective data are lacking.

Staphylococcus schleiferi

Staphylococcus schleiferi consists of two subspecies, the coagulase positive *S. schleiferi* subsp *coagulans* and coagulase negative *S. schleiferi* subsp *schleiferi.* These are less common causes of infection compared with *S. pseudintermedius* and *S. aureus*, however failure of many diagnostic laboratories to differentiate these organisms from *S. pseudintermedius* (*S. schleiferi coagulans*) and other coagulase negative staphylococci (*S. schleiferi schleiferi*) hampers proper assessment of their role in disease.

Staphylococcus schleiferi coagulans can be isolated in 0.8-4% of healthy dogs and 0-2% of healthy cats [6, 8, 10]. Colonization with methicillin-resistant *S. schleiferi* (MRSS) has been identified in 0-2% of dogs [6, 8, 15] and MRSS infections are being increasingly reported [13, 52, 53].

The most common clinical manifestations of *S. schleiferi coagulans* infection are pyoderma and otitis externa, but other opportunistic infections such as urinary tract infection (UTI) and pneumonia have been reported [6, 13, 54-58]. These infections are clinically indistinguishable from disease caused by other staphylococci, although it has been suggested that this species may tend to produce more superficial skin disease compared to *S. pseudintermedius* and *S. aureus* [13].

Less in known about *S. schleiferi schleiferi*, in large part because speciation of coagulase negative staphylococci is uncommonly performed by diagnostic laboratories. Colonization rates are unclear, but it is likely that *S. schleiferi schleiferi* is present in or on a small percentage of healthy dogs and cats. It has been implicated as a cause of pyoderma and otitis [13, 55, 57], and methicillin-resistant infections, while poorly characterized, presumably do the same.

Coagulase negative staphylococci

Epidemiology

Coagulase negative staphylococci (CoNS) are very common and generally of limited virulence. The prevalence of colonization is high [59], and with adequate effort CoNS could probably be found at one or more sites from most (if not all) dogs. *Staphylococcus xylosus, S. epidermidis* and *S. sciuri* are commonly isolated from healthy dogs [59-61], but various other species can be found. Colonization with CoNS is also common in cats, with high isolation rates from skin, saliva and the vagina [11, 12, 62]. *Staphylococus felis* appears to be most common, with *S. haemolyticus, S. epidermidis, S. simulans* and *S. saprophyticus* also isolated [11, 12]. They are commonly isolated from the skin, nasal and oral cavities, pharynx, perineal mucosa, gastrointestinal tract and conjunctiva. The preferred site of residence of different CoNS varies, and some species are restricted to specific body sites.

While colonization with CoNS is common, infection is not. CoNS infections may be overdiagnosed because CoNS can be isolated as contaminants from various superficial body sites. In human medicine, CoNS are primarily a concern in hospitalized individuals [63]. Community-associated CoNS infections in humans are usually UTIs caused by *S. saprophyticus*[63]. The situation may be similar in dogs and cats, with most CoNS being of minimal pathogenicity but some species (i.e. *S. schleiferi schleiferi* and *S. felis*) being potentially important causes of community-onset disease.

Methicillin-resistance is not uncommon in commensal CoNS. Studies have reported prevalences ranging from 5-13% in healthy dogs and 5% in cats [16, 31, 32, 64]. As with other staphylococci, methicillin-resistant strains are inherently no more pathogenic than methicillin-susceptible strains, and the implications of colonization with MR-CoNS are typically inconsequential.

Clinical Presentation

Primary infections are uncommon and evaluation of clinical disease caused by MR-CoNS is complicated by difficulties in actually diagnosing infection. It is likely that many false-positive diagnoses are made, particularly in skin and soft tissue infections, based on isolation of CoNS that are simply present at the infection site as contaminants. Infections, when they occur, are opportunistic and can involve various body sites, but this area has been poorly described.

While CoNS are generally considered as a group, it is possible that there are differences between CoNS species. This mainly relates to three organisms; *S. schleiferi* subspecies *schleiferi, S. epidermidis* and *S. felis*. *Staphylococcus schleiferi schleiferi* and *S. epidermidis* have been implicated as a cause of pyoderma and otitis [13, 55, 57, 65]. A primary role of *S. felis* in UTIs in cats has also been suggested [66]. These species may, therefore, be relevant pathogens in community-associated disease, unlike most other CoNS.

Diagnosis

A suspicion of staphylococcal infection is based more on signalment and site of infection than any clinical, clinicopathological or diagnostic imaging result data. Cytological identification of clusters of Gram positive cocci, particularly with abundant neutrophils and intracellular cocci, is suggestive.

Isolation of staphylococci from an infected site is the standard for diagnosis. While isolation of staphylococci tends to be relatively easy, interpretation of results can be challenging in some cases because of the presence of staphylococci as part of the commensal microflora. Therefore, consideration must be given to whether the organism is a cause of infection or simply present at the site of infection. This is often of greatest concern in skin and ear infections, which are also the most common locations of staphylococcal infection, and with CoNS.

In general, isolation of coagulase positive staphylococci from a site where staphylococcal infections are common is strongly suggestive. Isolation of staphylococci from sites that are expected to be sterile (e.g. blood) is essentially diagnostic as long as the sample was properly collected. Determination of the relevance of isolation of CoNS is more difficult. Isolation of CoNS from a superficial site should be interpreted with caution as this could represent infection or contamination. If a CoNS and other potential pathogen are identified concurrently, the CoNS is typically considered a contaminant. Speciation of CoNS to identify species that are potentially more relevant (i.e. *S. epidermidis, S. schleiferi schleifer, S. felis*) might be of benefit but is uncommonly available. Isolation of CoNS from sterile sites (i.e. blood, pleural cavity) is more indicative of disease as long as samples were collected and handled properly. Since they are skin contaminants, low levels of contamination can occur in samples collected through skin sites. If quantitative or semi-quantitative culture results are provided, low growth (1+) of CoNS is of questionable relevance and quite possibly contamination, not infection.

Identification of methicillin-resistance is usually done through detection of phenotypic resistance (antimicrobial susceptibility testing). This can be problematic in some situations if proper methodology is not used. Methicillin testing is not performed because methicillin is poorly stable *in vitro*. Oxacillin was used for detection of methicillin-resistance in MRSA but has recently been supplanted by cefoxitin, since cefoxotin testing is less prone to false negative results with MRSA. However, cefoxitin is not optimal for MRSP [67, 68], and oxacillin appears to be more sensitive. Resistance to either oxacillin or cefoxitin is an indication of methicillin-resistance. Clinicians should be wary of multidrug resistant staphylococci that are reported as methicillin susceptible, since this is rarely true and in most situations, these are truly methicillin-resistant. Detection of PBP2a by latex agglutination test or *mecA* by PCR can be used for confirmatory testing, but this is rarely done clinically.

One particular weakness of diagnostic testing in some regions is inadequate speciation of staphylococci. While there has been

general improvement, some laboratories still do not speciate coagulase positive staphylococci or differentiate *S. aureus* from other coagulase positive staphylococci. This is of concern for a few reasons. One is to be able to perform proper antimicrobial susceptibility testing. Testing guidelines for *S. aureus* are different from those for other staphylococci, and failure to properly identify isolates means that testing guidelines cannot be followed. Additionally, public health risks are different between MRSA and other methicillin-resistant staphylococci, and knowing the species is important for discussing risks and appropriate recommendations for management of animals in veterinary clinics and in households. Ideally, coagulase positive organisms should be identified to the species level, or at least to the level of *S. aureus* versus others (predominantly *S. pseudintermedius*). Speciation of CoNS is uncommonly available and of lesser importance, but as knowledge regarding different roles of CoNS in disease increases, it is possible that CoNS speciation will become more important.

Therapy

There is no standard approach to management of staphylococcal infections because of the highly variable nature of disease. General factors such as infection site, infection type and *in vitro* susceptibility are more important that the *Staphylococcus* species that is involved or whether it is methicillin-resistant or -susceptible. The simple fact that an isolate is methicillin-resistant should have minimal impact on the prescribed treatment beyond choice of the appropriate antimicrobial. There is no evidence that methicillin-resistant staphylococcal infections required longer, more intensive or different treatment than their susceptible counterparts. Factors such as surgical intervention and supportive care may be required but are not covered here.

When to treat

The first thing to consider when dealing with a potential methicillin-resistant staphylococcal infection is whether it needs to be treated. Colonization, contamination and subclinical infection (e.g. subclinical bacteruria) do not require treatment, and only situations where a methicillin-resistant *Staphylococcus* sp has been isolated from a clinical infection and where it is thought to be involved in disease require treatment.

Systemic Antimicrobials

Systemic administration may be required for many, but not all, infections. When systemic antimicrobials are used, general principles of antimicrobial therapy apply, considering *in vitro* susceptibility testing results, infection factors (e.g. presence of organic debris, accessibility of the infected site to antimicrobials) and patient factors (e.g. comorbidities, drug intolerance)

Broad recommendations for treatment of staphylococcal infections are difficult to make because of the variability in infection types and susceptibility patterns. Beta-lactam antimicrobials, including penicillin/beta-lactamase inhibitor combinations (e.g. amoxicillin-clavulanic acid), should not be used for methicillin-resistant staphylococcal infections. Diagnostic laboratories should report all methicillin-resistant staphylococci as resistant to all beta-lactams, however this is not always done. Occasionally, resistant staphylococci can appear susceptible to some beta-lactam antimicrobials *in vitro*, however this should be considered a false result and the use of beta-lactams in cases that are reported as methicillin-resistant is contraindicated.

In humans, fluoroquinolones are considered to be contraindicated for the treatment of MRSA infections because of poor clinical response and rapid development of resistance [69]. This has not been objectively investigated in dogs and cats, but there is no reason to suspect that it would be different in these species, so fluoroquinolones probably should be avoided whenever possible as treatments of resistant staphylococcal infections. Inducible clindamycin resistance is a potential problem, particularly with MRSA. With this phenomenon, isolates appear to be susceptible to clindamycin in vitro, however resistance is induced upon exposure in vivo and treatment failure is expected. One study of reported inducible resistance in 71% of MRSA strains from animals[70] while another study reported that 55% of erythromyin-resistant, clindamycin-susceptible MRSA from dogs were inducibly resistant [71]. Inducible resistance appears to be less common in S. pseudintermedius [71, 72]. Inducible resistance can be detected in vitro using a "D-test" however this is not widely available in veterinary diagnostic laboratories. In the absence of specific testing for inducible resistance, erythromycin-resistant isolates (or those where erythromycin susceptibility was not reported) should be considered potentially clindamycin resistant.

Antimicrobials that are often used include trimethoprim-sulfonamide, doxycycline, aminoglycosides and chloramphenicol, although susceptibility patterns and regulations regarding the use of certain drugs create significant regional variation in approaches.

Treatment options may be limited, particularly with MRSP, but at this point in time there is almost always one or more viable treatment options. However, highly drug resistant strains are increasingly encountered and few to no viable treatment options may be present in some cases. As methicillin-resistant staphylococci become resistant to more antimicrobials, there may be increasing pressure to use antimicrobials that are critically important in human medicine, such as vancomycin, linezolid, tigecycline and quinupristin-dalfopristin. The use of drugs such as these, which are critically important for treatment of serious multidrug resistant infections in humans, raises many ethical questions. Concerns about the use of these drugs include increased pressure towards resistance and subsequent transmission to humans, since transmission of MRSP and MRSA between animals and humans clearly can occur. These concerns are often matched with concerns about animal health and welfare if proper treatment is not provided and the fact that animal use compromises a miniscule percentage of overall use of these drugs. There is currently no consensus on the topic. At a minimum, these drugs should be reserved for situations where there are no other viable treatment alternatives, where the infection is not amenable to other (i.e. local) therapy and where the infection is life-threatening but potentially treatable. Prior to considering drugs such as these, all other therapeutic options should be considered, and ideally, an infectious diseases specialist should be consulted. Currently, it is rare to require drugs such as these because there is almost always another treatment option.

Local Antimicrobial Therapies

Local or regional administration of antimicrobials can deliver high antimicrobial concentrations and this can be a highly effective sole or adjunctive approach for many infections. Possible methods include intrarticular injection, regional perfusion, intraosseus perfusion and the use of antimicrobial-impregnated beads, collagen sponges, or other materials.

Topical Antimicrobials

Topical antimicrobial therapy may be a useful adjunctive or sole therapy. The ability to deliver high concentrations of antimicrobial directly to the site of infection, with minimal systemic exposure, can be very useful for treatment of superficial infections. Resistance of staphylococci from dogs and cats to topical antimicrobials such as mupirocin and fusidic acid is currently rare [73, 74] and the high local antimicrobial levels that can be achieved may largely offset acquired resistance.

The main limitation to topical therapy is the ability of topically-applied antimicrobials to reach the infection site. Thus, topical therapy is best reserved as a sole method for treatment of very superficial infections, such as superficial wound infection and surface pyoderma. Systemic therapy or a combination of systemic and topical therapy should be used for deeper infections or infections that do not respond completely to topical monotherapy.

Other Topical Treatments

Topical administration of biocides (antiseptics) can be a useful sole or adjunctive treatment for some skin and soft tissue infections. The potential efficacy of biocides involves a balance between the bactericidal activity of the compound and the tissue damage from biocide application, something that may be difficult to assess because of limited information regarding both efficacy and safety. Some compounds have profound antibacterial properties but are not useful because of the degree of tissue damage that can ensue. For some biocides, the cost-benefit of antibacterial properties and tissue damage are not well understood. As with topical antimicrobials, the ability to reach the infection site is the main limitation.

Available options include chlorhexidine, povidone iodine and benzoyl peroxide gel [75]. Other compounds such as accelerated hydrogen peroxide have also been proposed as topical therapies but there is currently little information about their use. Silver-coated dressings may be useful for treatment of skin and wound infections [76]. Essential oils are gaining popularity as topical therapies, although clinical data are currently lacking. Various essential oils, including tea tree oil, geranium oil, lavender oil and grapefruit seed extract have been shown to possess antibacterial properties, including activity against MRSA and MRSP [73, 77-79]. However, tissue damage is a potential concern as some essential oils can have cytotoxic effects on mammalian cells [80, 81]. Further study of efficacy and safety are required.

The use of honey has undergone a resurgence. Honey has bactericidal effects against various bacteria, including staphylococci, *in vitro* and *in vivo* [82-85]. There are differences in bactericidal activity between different types of honey, and the best-investigated honey has been Manuka honey, produced by bees feeding from the blossoms of *Leptospermum scoparium* (Manuka). Manuka honey can be a useful sole or adjunctive treatment of conditions such as wound infections or infected leg ulcers in humans.[82, 83]

Other Considerations

Both *S. aureus* and *S. pseudintermedius* are important causes of surgical implant-associated infections. These infections can be very difficult to treat because of the implant and associated biofilm. Often, antimicrobial therapy is inadequate for elimination of infection. Systemic antimicrobials may help control the infection, particularly if time is needed until he implants can be removed, but often infection will recur when antimicrobials are stopped if the implant is not removed.

Public Health Considerations

Staphylococcus aureus

Significant attention has been given to public health concerns regarding pets and MRSA. Given the importance of MRSA in human medicine, it is perhaps not surprising that serious concern has accompanied identification of MRSA in pets. However, as knowledge regarding MRSA advances it is becoming evident that while interspecies transmission of MRSA certainly does occur in households, human-to-animal transmission is probably most common. The role of pets in human MRSA infection is completely unclear. It is likely that pets play at best a very limited role in human MRSA infection, however zoonotic infections certainly cannot be dismissed.

Colonization of people in contact with infected or colonized dogs and cats (often with demonstration of the same strain in humans and animals) has been widely reported [24, 26, 28, 45, 86-88]. Pets have been implicated as sources of infection for humans in households [26, 87], however conclusions are often overstated. Virtually all studies have involved concurrent testing of people and pets. While finding the same MRSA strain in both groups strongly supports interspecies transmission, it cannot determine the direction of transmission. Further, since the MRSA strains found in pets are human epidemic clones, and because the average pet has little contact with other people or animals, it is most likely that a human household member would bring MRSA into the home, with the potential for subsequent dissemination to other humans and animals. This assessment should not be taken as an indication that there is no risk from pets, since regardless of how a pet is ultimately infected, it could still transmit MRSA to humans.

Numerous studies of MRSA colonization in veterinary personnel have been performed, reporting colonization rates of up to 18% in small animal veterinary personnel [89-92]. It cannot be determined with certainty that these colonization rates reflect acquisition of MRSA from animals; however identification of higher rates than present in the general population (1.5-3%) [93, 94], and the lack of other explanations as to why veterinary personnel would be at higher risk than others provide support of occupational origin. Whether this constitutes a significant health risk for veterinary personnel is unclear. There are limited reports of MRSA infection in veterinary personnel that have worked with infected or colonized animals [95, 96], along with numerous anecdotal reports. Further, the high rates of colonization could increase the risk of infection in some situations such as if colonized veterinary personnel undergo surgery or are admitted

to hospital. The other concern about high MRSA colonization rates in veterinary personnel is the potential for veterinary clinics to act as reservoirs of MRSA, resulting in infection or colonization of patients and potentially subsequent exposure of patients' families.

The true role of pets in human MRSA infections is impossible to determine at this point. Given the epidemic of community-associated MRSA infections in people and endemic MRSA in human healthcare facilities, pets certainly play a minor role in human infections. Yet, with the scope of this problem, a minor role from a population standpoint could still represent an important source of infection. The potential role of pets in human MRSA infections should be considered, but in a balanced manner.

S. pseudintermedius

There is currently limited public health concern regarding MRSP . *Staphylococcus pseudintermedius* infections have been reported in humans [97-102], yet these appear to be very rare. There are very few reports of MRSP infections in humans [103], however that must be tempered with the understanding that MRSP has only recently become common in animals and that there is some potential for misdiagnosis of *S. pseudintermedius* as *S. aureus* by medical diagnostic laboratories, depending on the methods that are used [104].

Because of the very high prevalence of *S. pseudintermedius* colonization in healthy dogs and cats, human exposure must be very common. Accordingly, the low reported colonization rates in veterinary personnel and pet owners (1-4%)[8, 105] and rarity of human infection indicate limited risk from contact with pets. Since MRSP is inherently no more virulent than methicillin-susceptible *S. pseudintermedius*, the risks posed by MRSP should be similarly low. To date, reports on zoonotic transmission of MRSP are scarce. Transmission of MRSP between dogs and people is likely based on reports of indistinguishable isolates from people and dogs [106, 107] and isolation of MRSP from a small percentage of owners of dogs with MRSP pyoderma [108]. The risk posed by MRSP should be considered low, however given the highly drug resistant nature (and associated treatment difficulty) care should be taken to use good infection control practices around infected animals in households and veterinary clinics.

Other staphylococci

Public health concerns regarding other staphylococci are currently limited. Human *S. schleiferi coagulans* infections are extremely rare. In one case, a dog with otitis was thought to be the source of *S. schleiferi coagulans* endocarditis in an immunocompromised person [109], however it was not possible to confirm that the dog was the source. *Staphylococcus schleiferi schleiferi* is likely a human commensal, so the risk posed by infected animals is probably low.

Other coagulase negative staphylococci are common in both animals and humans. While many of the same CoNS species can cause disease in both people and pets, it is unlikely that animals are relevant sources of human infection.

Infection Control Practices

Decolonization

Active elimination of MRSA colonization in humans is a contentious issue. Active decolonization, often using topical antimicrobials such as mupirocin or fusidic acid, sometimes with concurrent oral antimicrobial therapy or antiseptic baths, is used as a means of MRSA control in some situations in some regions, although international consensus is lacking. The need for decolonization therapy in otherwise healthy individuals in the community is controversial and decolonization is most commonly used in specific populations, such as healthcare workers, patients undergoing surgical procedures, patients in intensive care units or individuals in households with recurrent MRSA infections.

In some respects, active elimination of MRSP or MRSA colonization in dogs and cats could be desirable to reduce the risk of development of clinical infection or transmission to other individuals, including people. However, there is currently no evidence that therapy to eliminate colonization is indicated or even potentially effective in dogs and cats. Adequate topical application of an antimicrobial to the entire nasal passages of a dog or cat is not realistic, and incomplete treatment could lead to further resistance. Another major consideration is the fact that MRSA colonization appears to be transient in most if not all dogs and cats [28, 35, 39]. The use of good general hygiene measures to reduce re-infection almost invariably results in spontaneous decolonization, so it is questionable whether active decolonization is even indicated.

Similarly, decolonization therapy is not recommended for dogs and cats carrying MRSP. While data are lacking, it is possible that MRSP could colonize dogs and cats for prolonged periods of time, particularly compared to MRSA, since it is presumably more adapted for dogs and cats than human MRSA clones. A way to eliminate colonization in long-term carriers, in animals with recurrent MRSP infections, or in animals about to undergo surgery could be desirable, however there is no information available indicating whether decolonization could be effective. Given the lack of evidence of efficacy and need, active decolonization therapy for MRSP is not currently recommended.

Screening

In humans, MRSA screening is an important infection control tool in some hospitals. It allows for prompt identification of MRSA carriers, with subsequent use of enhanced infection control practices to reduce the risk of transmission. It also allows for identification of individuals at increased risk for MRSA infection, and may modify empirical antimicrobial treatment if the person develops an opportunistic infection. Screening of people outside of healthcare facilities is rarely (if ever) performed.

When considering whether to screen for MRSA or any other pathogen, consideration must be given to the relevance of the results and the measures that will be taken based on the results. In companion animal veterinary practices, it is hard to justify routine MRSA screening from an infection control standpoint and there are few other situations where screening could be useful. Testing of pets for MRSA colonization is not indicated in situations where MRSA has been identified in a person in a household or when there are high-risk people in the household [110]. If a

pet was identified as colonized, the pet likely acquired MRSA from a person in the household. Standard recommendations would be to use good hygiene practices to allow the animal to naturally decolonize and to prevent reinfection. If the animal was negative, the household would still be considered high risk for MRSA exposure from the person's disease, so hygiene would be emphasized to reduce the risk of transmission of MRSA to the pet. Since the recommendations would be essentially the same, whether the result was positive or negative, it is hard to justify screening. The main situation when screening of pets might be indicated is in households with recurrent MRSA infections but only if the entire household (human and animal) is being concurrently evaluated and a plan is made regarding how to deal with colonized people and pets [110]. Even then, unless there would be a different approach for negative versus positive results, screening might be of limited use.

There are few indications to screen animals for MRSP carriage, apart from epidemiological studies. The main clinical situation where screening might be indicated would be when there is an increased likelihood that the animal is an MRSP carrier and it is to undergo elective surgery. In such a situation, knowing MRSP status might result in modification of infection control practices and perioperative antimicrobial choices.

Based on current knowledge, there is no indication to screen animals for carriage of other methicillin-resistant staphylococci. Routine screening of veterinary personnel for colonization with any methicillin-resistant *Staphylococcus* sp. is not indicated.

Conclusion

In a short period of time, methicillin-resistant staphylococcal infections have emerged as important problems in companion animal medicine. As infection rates, continue to increase, along with resistance to further antimicrobial classes, methicillin-resistant staphylococci will pose a significant challenge to veterinary practitioners for management of individual cases, prevention and control of hospital-associated infection, prevention of zoonotic infections, and counseling of clients.

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BSAVA Guide to Procedures in Small Animal Practice (First Edition)

Edited by Nick Bexfield and Karla Lee

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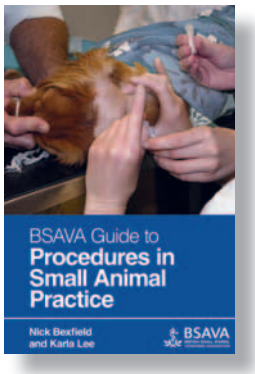

This practical pocket size guide with summarised facts in an A-Z fashion is truly a step-by step manual to the most common practical techniques that are encountered in daily veterinary practice. The procedures are mainly based on the earlier BSAVA publications which enable the reader to easily access more indepth information as well as references. The guide is thorough and well written and the editors deserve compliments for providing us with this handy book.

The content of the guide is made up of routine procedures as well as emergency procedures. I particularly appreciate the included indications and contraindications for each procedure which serve as a good reminder for us all. There are also a few parts on clinical examination of the major body systems and protocols for management of selected emergencies. Also included are helpful sections on extended diagnostics such as the ACTH stimulation test and water deprivation test. Some could argue that the guide should only contain practical procedures but personally I appreciate the extension to some selected investigative and examination protocols. The neurological examination however is in my opinion a bit too detailed and lacks a systematic approach to the localisation of lesions in the neurologic patient. An addition of a flow chart like the one presented in the part regarding cardiopulmonary-cerebral resuscitation would certainly improve this part. A similar flow chart for emergency treatment of urinary obstruction would also be valuable.

Guide books like this enable veterinary practitioners to easily follow standard operating procedures. This guide certainly contributes to this and is, without doubt, a book for every vet in practice.

Some of the procedures are nicely illustrated which is an helpfull aid especially in emergency situations with procedures that are not encountered every day. The routines are orderly arranged by numbers. A page reference in conjunction with the current alphabetic register, although not necessary, would be helpful.

This first edition is an excellent publication and there are possibilities to develop it even more in the next edition. It would be valuable to add some more procedures also seen in practice such as the management of heartfailure, principles of F.A.S.T. echocardiogram, management of the pregnant bitch in conjunction to labour, skull trauma, and the management of suspected spinal trauma to give some examples. The difficult task is to not add too much as the conveinience of the size of this book is essential. To improve the sustainability a plastic cover could be considered as this book will undoubtedly be well worn. This is a guide that will be sought after in all of Europe and probably overseas as well. It would not surprise me if this is the new BSAVA bestseller!

Alexandra Vilén DVM (Sweden)

BSAVA Manual of Canine and Feline Rehabilitation, Supportive and Palliative Care. Case studies in patient management.

Edited by Samantha Lindley and Penny Watson

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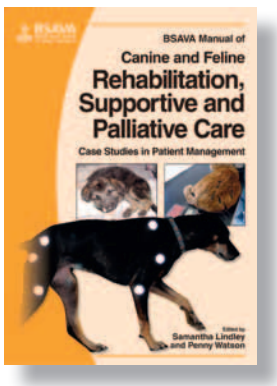

In the best BSAVA tradition this Manual targets the veterinarian, nurse/technician, and other professionals working in the private or referral small animal practice.

I might offer a biased review as I really believe in rehabilitation and especially palliative care as defined on page 1 "we all give palliative care in dogs and cats suffering with chronic diseases". I found very valuable the initial critical assessment of resources, distress and outcome, which can help in defining the magnitude of the therapeutic measures required and set humane endpoints.
The driving red line is to offer the busy veterinary professional an evidence based update of core topics in supportive care. Accordingly, in Chapters 1 to 11 the "must know" notions in acute and chronic pain management, clinical nutrition (addressing both positive and especially negative caloric balance) and physical therapies are summarised. Each Chapter incorporates practical 'Key Points' in boxes that highlight the important concepts. I appreciated the efforts of authors to present evidence based information, supported by the most updated and relevant literature. This allows the interested veterinary or animal professional to have an opportunity for in depth reading on specific topics in his/her spare time.
With a case based didactical approach these main concepts are systematically applied thereafter to individual cases, classified by systems. The cases "as they really happen in practice" are accompanied by numerous illustrations making them very realistic and the Manual attractive. Whilst reading through the book, I recalled many patients and cases both with their frustrations and successes.
Great emphasis is given to "a multimodal therapy" resulting from the interplay between pharmaceutical, physical and alternative methods of treatment and from the synergism of the knowledge and passion of many dedicated professionals in the practice's team. The final goal was to improve the welfare and quality of life of the small animal patient by offering state of the art medicine.
The Manual reflects this idea from the start as it is the result of the co-work of a remarkable list of internationally renowned specialists. Sincere compliments should be given to this great team and to the two Editors for guiding them to a didactically modern and attractive book.

To conclude this Manual is a very valuable instrument allowing the private practitioner to offer knowledgeable and state of the art rehabilitation, supportive and palliative care to a broad spectrum of patients, ranging from surgical, internal medicine, and pain cases. This will improve both animal welfare and client and operator satisfaction.

I would like to conclude by asking the Authors their experience and opinion regarding analgesic radiotherapy which might well find an indication in the cases of some of the patients discussed in this Manual. Possibly this could be included in the next Edition.
Enjoy reading!

Alessandra Bergadano
DVM, Dr.Med.Vet., Dip.ECVAA, PhD (CH)

Small Animal Neurology – an illustrated text

Edited by Andre Jaggy and Simon Platt

Published by Schütersche Verlagsgellschaft GmbH & Co. KG, Hanover.
http://www.buecher.schluetersche.de 2009
580 pages, Hardback,
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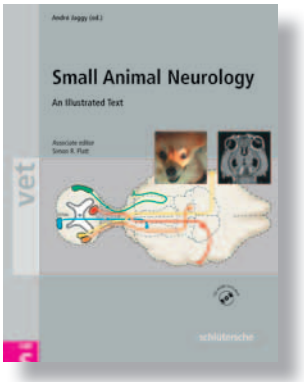
€ 166 Approx £ 140

This is a very well-presented book that should be added to the collection of any specialist in veterinary neurology or indeed anyone with an interest in this subject. Its price of 166 euros at (£140) may deter some potential purchasers. However, it has 580 pages of good quality paper bearing many excellent photographs and drawings – it's certainly



worth the money. This second edition, again principally edited by Andre Jaggy, has been generally upgraded and contains two excellent new sections on emergency neuromedicine and comparative sectional anatomy of the canine and feline brain. Another additional attribute is a CD-Rom featuring the details of clinical investigation together with a sound commentary and also a number of clinical cases with a stated localisation. Unfortunately results of ancillary tests and diagnoses are omitted and there is no sound track for these cases.

Originally written in German, the translation into English has been very competently done. Errors do occur in the text but it is the duty of the proof reader to spot those, eg. lumber (p.517), siseases (p VIII), Charle's (p.1). I was surprised to find gabapentin missing from the Appendix 5 (Drugs) but I can forgive that small omission in an otherwise excellent book. There were 43 contributors to this book, all well-known established experts in veterinary neurology; to a certain extent this very fact has been responsible for a lack of cohesiveness in the writing. Sometimes it is difficult to gather all the information on a particular topic; more cross-referencing would have been helpful since the Index does not always come to the reader's aid. However, some patience and determination will be rewarded since the derived information is likely to be found somewhere. Unusually the list of Contents is extensive and more helpful than the Index but patience is needed again as it is not alphabetically arranged. The acronym 'VITAMIN D' classification system is applied throughout the text with all but one letter given a clear definition; for some reason I for Idiopathic is omitted.

In a very competitive field this book stands out as the most comprehensive compilation of small animal neurology currently available; it certainly has my recommendation.

Geoff Skerritt
BVSc MIBiol CBiol DipECVN FRCVS (UK)
RCVS & European Specialist in Veterinary Neurology

Calendar of main European National Meetings and other continuing education opportunities

WSAVA & FECAVA Congresses (Red)
Principal annual meetings (blue)

A list of the addresses and telephone numbers of the Secretariat or person holding information is attached.

2011				
2-3 April	ESAVA	Tallinn	CE Clinical genetics and haematology	English
9-10 April	VÖK	Wels	Neurology Seminar & Workshop	German
9-10 April	CSAVA	Hradec Kralove	SA Emergency Medicine	Czech, English
18-22 April	ESAVS	Luxembourg	Radiology I	English
26 April	BSAVA	Gloucester	CE Respiratory diseases of the dog and cat: A comprehensive review	English
28 April	BSAVA	Manchester	CE Endocrinology II: Endocrine emergencies, collapse and effect on blood pressure	English
28-30 April	NACAM	Amsterdam	Voorjaarsdagen	Dutch, English
5 May	BSAVA	Belfast Northern Ireland	BSAVA Dispensing Course	English
10 May	BSAVA	Gloucester	CE Trauma Patients	English
12 May	BSAVA	Gloucester	CE Seizures: Managing your worst nightmare	English
14-15 May	VÖK	Rankweil	Urogenital tract Surgery Seminar	German
19-21 May	SVK/ASMPA	Interlaken	Annual Congress	German, French, English
19-21 May	ESAVS	Luxembourg	Ultrasonography	English
20-25 May	ESAVS	Estoril (P)	Excellence in Veterinary Therapy: Cardiology & Oncology	English
24 May	BSAVA	Kettering	CE Geriatric Cats	English
24 May	BSAVA	Gloucester	CE Too much fluid, Too low flow: Caring for the patient with heart disease	English
26 May	BSAVA	Manchester	CE Interpretation of biochemical data and an introduction to diagnostic cytology	English
30-31 May	HVMS/ Branch of Companion Animals	Thessaloniki	Intensive care in the dog and cat /Continuing Education Course for Companion Animal Practice	Greek, English
7 June	BSAVA	Gloucester	CE Bleeding, Anaemia and transfusion medicine	English
13-17 June	ESAVS	Halmstad (S)	Dentistry II	English
14 June	BSAVA	Gloucester	Introduction to practical cytology	English
20-24 June	ESAVS	Berne (CH)	Emergency and Critical Care II	English
20 June - 1 July	ESAVS	Toulouse (F)	Ophthalmology II	English
21 June	BSAVA	Kettering	Geriatric Dogs	English
23-26 June	ISFM (formerly ESFM)	Vienna, (A)	Annual Congress Feline Opthalmology and feline respiratory disease	English
28 June	BSAVA	Gloucester	CE I'll never see a case of this… Will I? Emerging infectious diseases of dogs and cats	English
30 June	BSAVA	Manchester	GIT I: Diseases of the canine and feline liver and pancreas	English
4-15 July	ESAVS	Vienna (A)	Dermatology I	English
5 July	BSAVA	Gloucester	CE Sepsis, SIRS, and support	English
16-20 July	ESAVS	Estoril (P)	Cardiology I	English
18-20 July	ESAVS	Luxembourg	Radiology II - Advanced	English
18-29 July	ESAVS	Vienna (A)	Dermatology III	English
23-24 July	VÖK	Ried/Traunkreis	2. Cardiology-Forum	German
28-30 July	ESAVS	Vienna (A)	Rehabilitation & Physiotherapy of Small Animals I	English
8-12 August	ESAVS	Berne (CH)	Neurology III / Neurosurgery	English
15-19 August	ESAVS	Berne (CH)	Neurology IV / Neurosurgery	English
17-21 August	ESAVS	Luxembourg	Diagnostic Ultrasound I	English
19-23 August	ESAVS	Luxembourg	Cardiology II	English
20-24 August	ESAVS	Berne (CH)	Neurology I	English
22-26 August	ESAVS	Benalmádena (E)	Feline Medicine & Surgery I - Gastroenterology and Urinary Tract Diseases	English
24-28 August	ESAVS	Luxembourg	Cardiology III - Introductory Echocardiography	English
29 Aug. -2 Sept.	ESAVS	Benalmádena (E)	Feline Medicine & Surgery II - Infectious Diseases	English
29 Aug. – 2 Sept.	ESAVS	Vienna (A)	Soft Tissue Surgery I	English
1-3 Sept.	EVDS	Chalkidiki	European Congress of Veterinary Dentistry	English
7-10 Sept.	FECAVA/TSAVA	Istanbul	17th FECAVA EuroCongress	English, Turkish
8-10 Sept.	ESVD-ECVD	Brussels (B)	Annual Congress	English
8-10 Sept.	ESAVS	Bruno (CZ)	Exotic Pets Medicine & Surgery	English
12-16 Sept.	ESAVS	Luxembourg	Behavioural Medicine I	English

14 Sept.	BSAVA	Gloucester	CE Diabetes	English
15-17 Sept.	ESAVS	Giessen (D)	Surgery / Lasersurgery in Veterinary Medicine	English
16-18 Sept.	VÖK	Salzburg	26th Annual Congress	German, English
19-23 Sept.	ESAVS	Milan (I)	Small Animal Reproduction III	English
22-24 Sept.	ESVN-ECVN	Trier (D)	24th Annual Congress ("Neurogenetics")	English
27 Sept.	BSAVA	Gloucester	CE A practical guide to oncology: No more lumps in your throat Part I	English
29 Sept.	BSAVA	Manchester	GIT II: Oesophagus, stomach and intestines	English
29 Sept. - 2 Oct.	AVEPA	Barcelona	AVEPA/SEVC Annual Congress	English, Spanish, French, German, Polish
2 October	LSAPS	Riga	WSAVA CE Dermatology	English
8-9 October	VÖK	Kufstein	Neurology, Ophthalmology, Gastroenterology Seminar	German
8-9 October	CSAVA	Hradec Kralove	!9th Annual Congress SA Endocrinology	Czech English
15-16 October	VÖK	Ried/Traunkreis	Urogenital tract Surgery Seminar	German
15-16 October	SkSAVA	Nitra	Annual congress - Nova Veterinaria 2011	English, Czech, Slovak
19- 22 October	ESVOT	Lyon(F)	Wetlab session in University	English ,French
24-28 October	ESAVS	Madrid (E)	Cardiology IV - Advanced Echocardiography	English
25 October	BSAVA	Gloucester	CE A practical guide to oncology: No more lumps in your throat: Part II	English
27 October	BSAVA	Manchester	CE Haematology	English
4-5 November	HVMS/ Branch of Companion Animals	Patra	Management of the acute abdomen in the dog and the cat/ Continuing Education Course for Companion Animal Practice	Greek, English
5-6 November	VÖK	Steyr	Ultrasound-Basic-Seminar	German
6 November	LSAPS	Riga	WSAVA CE Dermatology	English
10-11November	SSAVA	Uppsala	Haematology – haemostasis and inflammation	Swedish ,English TBC
14-25 November	ESAVS	Utrecht (NL)	Internal Medicine I	English
19 November	VÖK	Krems	X-Ray-Seminar	German
22 November	BSAVA	Gloucester	Medical neurology of the dog and cat: how to make sence of the wobbly, weak or collapsing patient	English
24 November	BSAVA	Manchester	CE Clinical Nutrition: Let food be your first medicine	English
26 November	VÖK/VUW	Vienna	Otitis-Workshop	German
2 - 4 December	AFVAC	Lyon	Annual Congress	French
3-4 December	SkSAVA	Smolenice	Small animal stomatology	English, Czech, Slovak
9-14 December	ESAVS	Davos (CH)	Excellence in Veterinary Therapy: Internal Medicine & Emergency Care	English

Advance notice		
2012	HVMS 28-29 January CE Rabbits and Rodents HVMS March Annual Congress FECAVA /WSAVA/BSAVA Birmingham April 12-15 April Voorjaarsdagen 26-28 April	ESVN Annual Congress 14-15th September VÖK Salzburg 21-23 September WAVD 7th World Congress of Veterinary Dermatology
2013	Voorjaarsdagen 25-27 April	

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